IN THE BEGINNING

Geoscience Features Picture Library

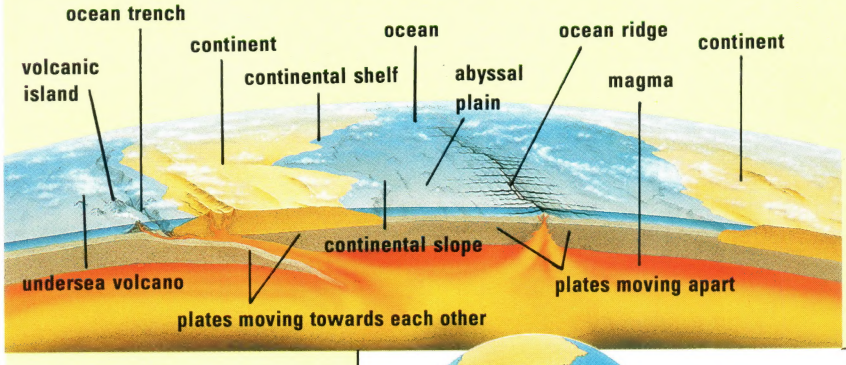
THE OCEANS WERE BORN from the fiery insides of a newly-formed Earth. Water vapour that escaped with gases in great volcanic eruptions eventually cooled and fell as unremitting rain over the rocks. And as it fell, the rain gathered in huge hollows in the Earth's crust, forming the first oceans, 4,000 million years ago.

A journey to the bottom of the ocean would reveal a view of mountains, valleys and plains larger than any found on land above. When a continent enters the ocean, it continues to descend for nearly 200 metres below sea level. This is the continental shelf, whose edge marks the true boundaries of a continent

Beyond the edge, a steep gradient marks the continental slope, which then plunges further into the

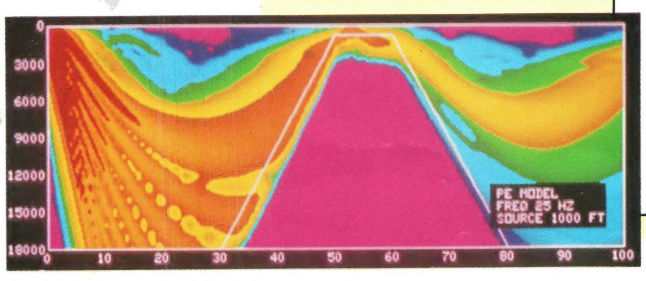
***Angry bursts** of fire and brimstone rip through a volcano – a terrifying reminder of the origins of the oceans. The newly-formed thin crust on the molten, young Earth similarly gave way to huge eruptions of hot gas from within. The water vapour that condensed fell as torrential rain, and formed the first rivers and oceans billions of years ago.*

PLATE TECTONICS

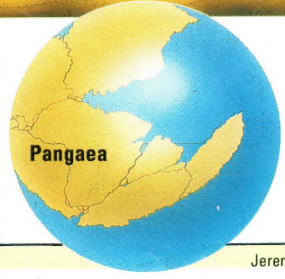


The ocean bed lies on the Earth's crust. A slice through Earth shows the crust made up of plates. The movement of these plates is explained by the theory of plate tectonics.

***Computer graphics** translate sound transmissions into a picture of an undersea mountain. It is more than 4,500m tall. A sea mount is formed by magma from beneath the crust. It solidifies and builds up over thousands of years to form a towering volcanic mountain.*



Woods Hole Oceanographic Institution



Only one supercontinent, Pangaea, existed about 200 million years ago. As the Earth's plates shifted, parts of Pangaea separated to form the seven main land masses.

Jeremy Gower

CORAL REEFS AND VOLCANIC ISLANDS

Coral reefs often form around volcanic islands. Billions of reef-building coral lay down the framework of the reef, and skeletons of various marine organisms then fill in the gaps. Over thousands of years, as the sea level rises or the sea bed sinks under the weight of sediment, the volcanic island may slowly submerge. However, more coral continues to grow on top of the dead coral. Only a circular group of islands – an atoll – is left on the surface. But it is still attached via the old dead coral to the sunken volcano.

Kuoni Travel

water for another 3,000 metres. After this, it starts levelling out at a much gentler incline where it is known as the continental rise.

The continental rise finally levels out at 3,700–4,000 metres when it becomes the abyssal plain. This is the floor of the ocean, the base from which all land ultimately rises.

On the move

Imagine this base as a giant jigsaw made up of seven large plates and several smaller ones. Each plate is approximately 100 km deep and floats on a bed of hot, semi-liquid rock called magma. Because of the sluggish movement of the magma below, the plates can be dragged around up to 15 cm each year. This process is explained by the theory of plate tectonics.

On the ocean floor, the edges of the plates are principally marked by a ridge of mountains or a trench.

When two plates move away from each other, magma from inside the Earth is spewed up to fill the gap. As it comes into contact with the cold ocean water, it solidifies to form new rocks. This process, known as seafloor spreading, slowly forces the continents apart by up to 10 cm a year.

Over millions of years, the new rock builds up to form undersea mountain ranges. These ocean ridges run along the floors of each of the major oceans, forming a continuous network.

The opposite of ocean spreading, ocean shrinking, takes place when two plates move towards each other and collide. One plate is pushed under the other, and this forms an ocean trench.

The Marianas trench, 2,575 km east of the Philippines in the Pacific, is 11,034 metres deep – more than twice the depth of the average ocean floor. It is the deepest trench in the world.

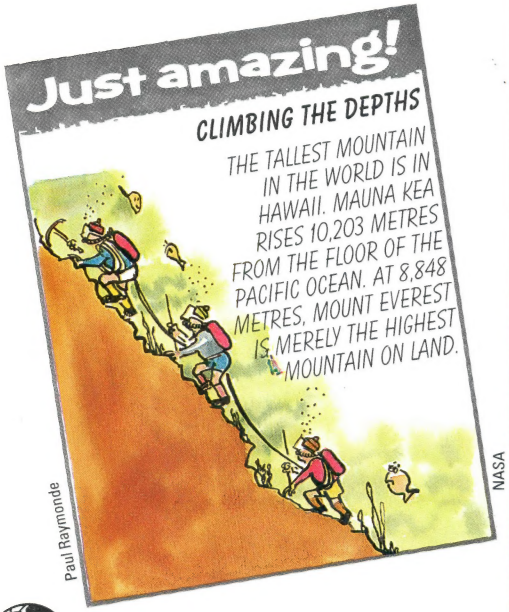
As the two plates slowly grind towards each other, they may sometimes lock together. When they eventually break free of each other, the sudden movement is felt as an earth tremor, which may set off an earthquake.

In 1985, an earthquake that started 64 km off Mexico's Pacific coast, caused widespread damage inland and killed 7,000 people, mainly in Mexico City, which stands on unsolidated lake sediments.

Earth, fire, water

The tremendous force and heat produced when a plate edge descends sometimes weakens the surface of the sea floor so much that magma from below is able to burst through. As a result, chains of volcanoes may form along one side of the ocean trench. Peaks of many such volcanoes emerge from the sea as volcanic islands.

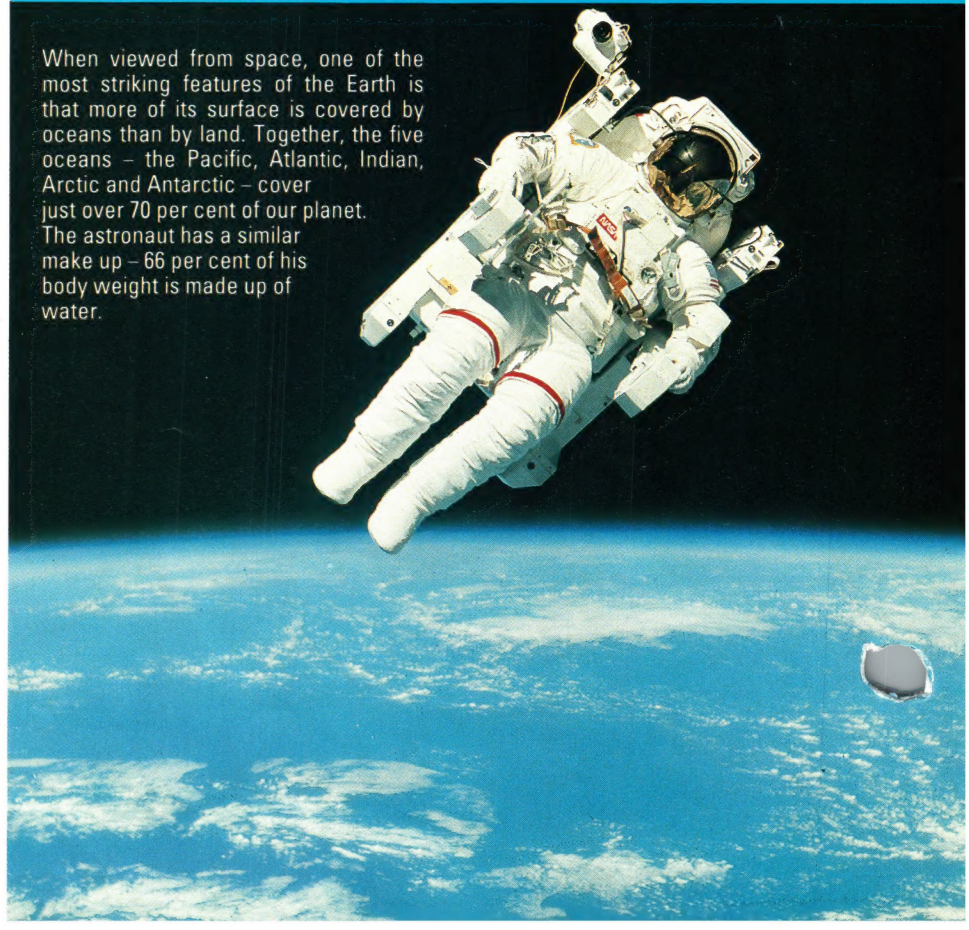
Sometimes volcanic islands are found in more unexpected places. The Hawaiian Islands, many of them active volcanoes, lie in the middle of the Pacific plate. Here, the 'hottest spot' on Earth is constantly erupting with magma. As the plate moves over the hot-spot, a chain of volcanic islands is formed.



Paul Raymonde

THE WATERY PLANET

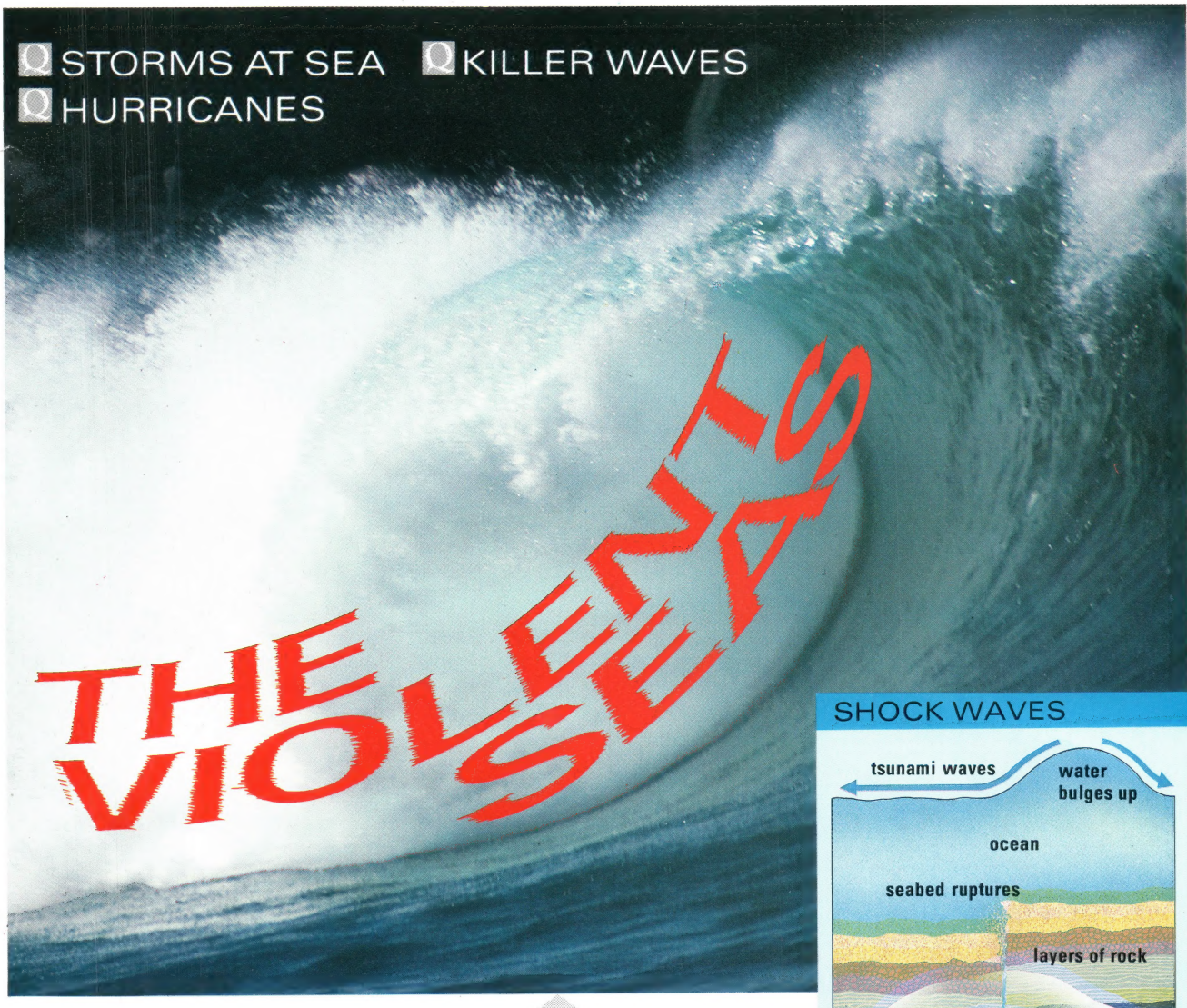
When viewed from space, one of the most striking features of the Earth is that more of its surface is covered by oceans than by land. Together, the five oceans – the Pacific, Atlantic, Indian, Arctic and Antarctic – cover just over 70 per cent of our planet. The astronaut has a similar make up – 66 per cent of his body weight is made up of water.



NASA

STORMS AT SEA
KILLER WAVES
HURRICANES

THE VIOLENT SEAS



Planet Earth Pictures/Le Roy F Grannis

***A giant wave** is a surfer's dream. But even these 'giant' waves are dwarfed by killer waves, known as tsunamis, which can reach heights of over 30 metres. When they hit land, they cause havoc and destruction.*

A STORM AT SEA CAN BE spectacular – seen from a safe distance. As the wind passes over the water's surface it creates waves. But if the force of the wind is strong, powerful waves are generated, gathering momentum until a barrier in their path causes them to break with full force.

Not all waves are of equal height. This is partly because the wind seldom blows at a constant speed. When the wind dies down, wave length is maintained but wave height decreases gradually. Where there are no barriers in their path, wave crests may carry over vast distances.

When waves created in different places come together, they produce a confused sea state. Boats may be completely overwhelmed by a storm at sea – getting swamped, smashed, or both, by the huge quantity of water falling on them.

The full force of a wave is not realized until it reaches the shore. As it sweeps in towards land, contact with the sea-bed slows down the lower part, but the wind keeps the top moving on. The wave becomes steeper, begins to overhang, and finally crashes down. On steep shores, waves do not have time to slow down. Suddenly, their way is barred and they smash against the rocks with tremendous force – 100 tonnes per square metre is not unusual.

Spinning destruction

Winds exceeding Force 12 (over 117 km/h) can devastate anything that lies in their path. They are known as hurricanes in the Atlantic, typhoons in the North Pacific and cyclones in the Indian Ocean and around Australia. These great storms start when scattered cloud clusters of tropical thunderstorms are gathered together into a whirling spiral by the Earth's rotation. At the centre of the spiral is a column of low pressure – the eye.

Because of the low pressure, air is sucked into the spiral with great force, resulting in violent winds. These set up huge waves at sea, which have a devastating effect.

Hurricanes may persist for up to ten days, and although the path they will follow can be predicted to some extent, unexpected twists and turns are common.

A water spout is another example of the sea being whipped up. This is rather like a liquid tornado. Warm air rising from the sea creates a central column of low pressure which draws up a swirling rising wall of water.

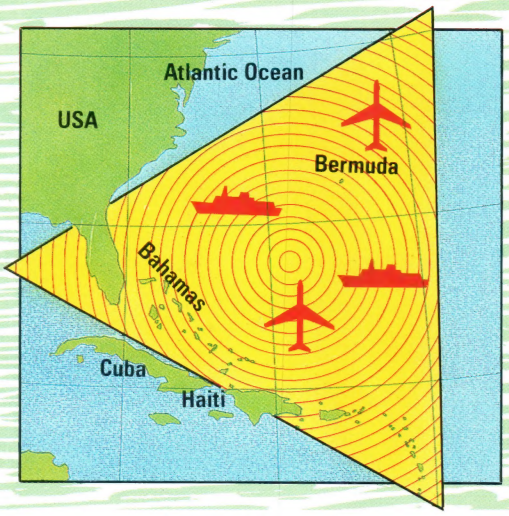
SHOCK WAVES

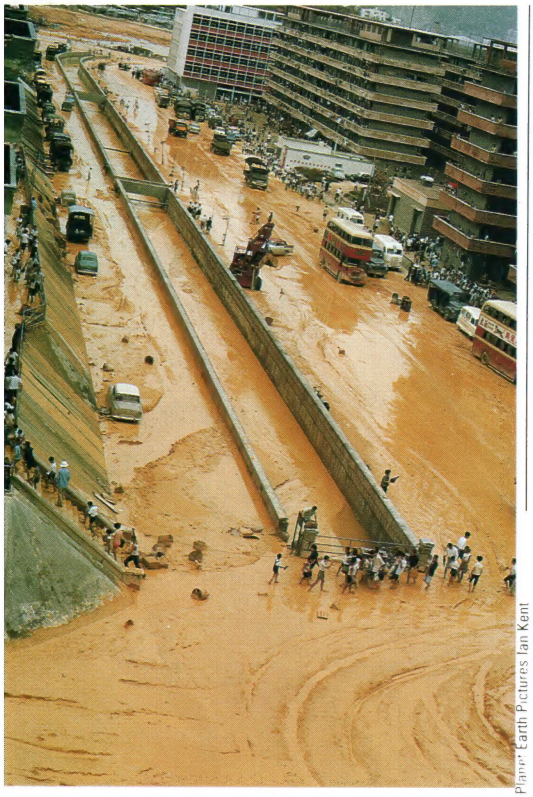
Alan Sattie

Tsunamis, often wrongly called tidal waves, mostly occur in the Pacific Ocean, particularly in the 'earthquake belt' off Japan. A Tsunami Warning System, with its nerve centre at Honolulu, in the middle of the ocean, monitors seaquake activity and warns all the Pacific countries when a tsunami is imminent.

THE BERMUDA TRIANGLE

Known variously as the 'Triangle of Death' or 'Graveyard of the Atlantic', the Bermuda Triangle is an area off the eastern coast of the USA, around Bermuda, where more than 1,000 people and several ships and aircraft have been mysteriously sucked into oblivion. According to a popular theory, extra-terrestrial activity – or even the Lost City of Atlantis – is responsible for these losses. But more scrupulous research suggests that most of the accidents had natural causes.




Planet Earth Pictures Ian Kent

After a cyclone, *life returns to normal in Hong Kong. The effects can be devastating, not just in terms of damage to property but in loss of life. A cyclone in Bangladesh in 1970 caused one million deaths.*

When a low pressure system – depression – passes quickly across the sea, the water level suddenly drops, then rises. A great swell is created, known as a storm surge, which can flood huge areas as it hits land.

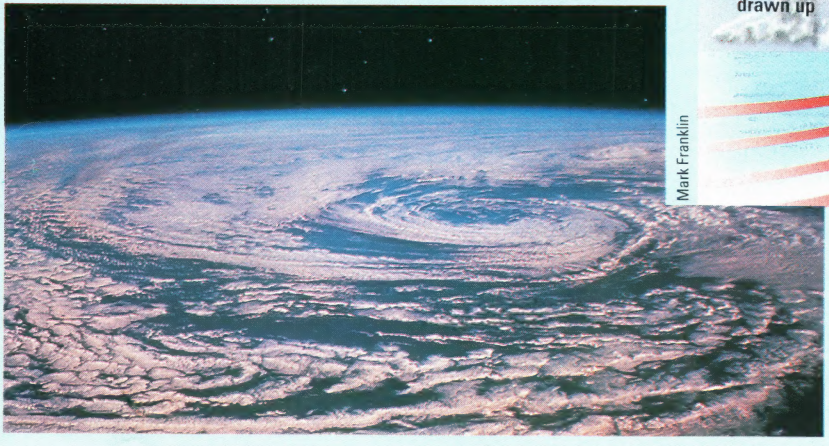
Tsunamis

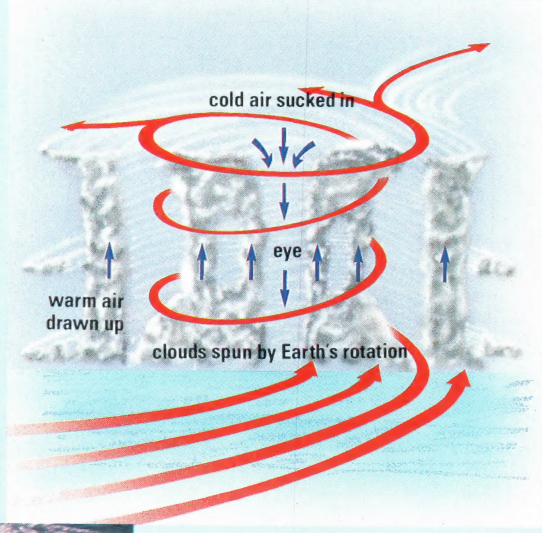
Just as terrifying as rough seas, are tsunamis, caused by earthquakes and volcanic eruptions in the ocean. Small earthquakes occur along the ocean ridges, where the Earth's crust is thin and hot. The largest ones are along the lines of collision of the plates.

The quake lifts the ocean floor, which buckles and collapses, and the shock tremors suddenly move the whole mass of water above, right from the ocean floor to the surface. As the tremors radiate outwards, the tsunami sweeps across the ocean at terrifying speeds of up to 720 km/h.

At first, tsunamis are very small and may not be noticed in the open sea. However, as they come to shallower water, they are slowed down by the drag of the sea-bed and the wave builds into a vast wall of water with an awesome power for destruction. They hit the coastline with tremendous force. Boats are thrown high up on the shore, land is filled with sea water and houses destroyed. The highest, recent tsunami occurred off south-west Alaska in 1964 and reached 67 metres.

THE EYE OF THE HURRICANE


Tony Stone Worldwide



The eye of a hurricane can be seen clearly from space. Around the still, quiet centre the most damage is caused as warm air spins upwards in a spiral (above). Storm clouds form while the low pressure at the centre sucks in cooler, heavier air.

A place in the UNIVERSE

THE MILKY WAY | PLANET OF LIFE | METEOR BOMBARDMENTS

IN THE VASTNESS OF SPACE, lost among the countless stars, an unremarkable planet spins around its own star. One fact makes this particular planet special above all others – it is our home, Earth.

The star it revolves around is the Sun, and together with the eight other planets – Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto – and their moons, they form the Solar System.

But the Sun is only one of billions of stars that go to form yet another grouping, a galaxy. Our Galaxy, the Milky Way, consists of about 100,000 million stars. Many of these stars may also be circled by planets, some of which may perhaps have life on them.

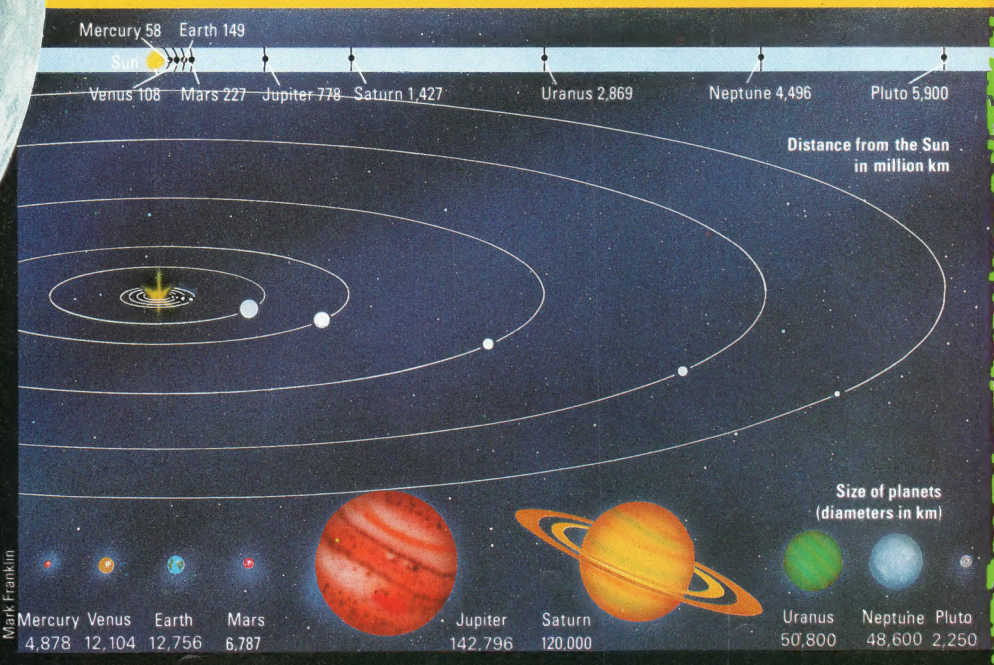
Incredible distances

Galaxies come in different shapes and sizes. They may be spiral or elliptical, or have no clearly defined shape at all. The Milky Way is a spiral galaxy, thick in the centre and tapering off to the sides, rather like a gramophone record. Our solar system lies about two-thirds away from the centre.

NASA Royal Obs... rgh

Earth orbits the Sun and spins in the vastness of space, among the brilliant star systems. These immense systems are called galaxies and they are the building blocks of the Universe. Our own Galaxy, the Milky Way, is one among billions in the Universe.

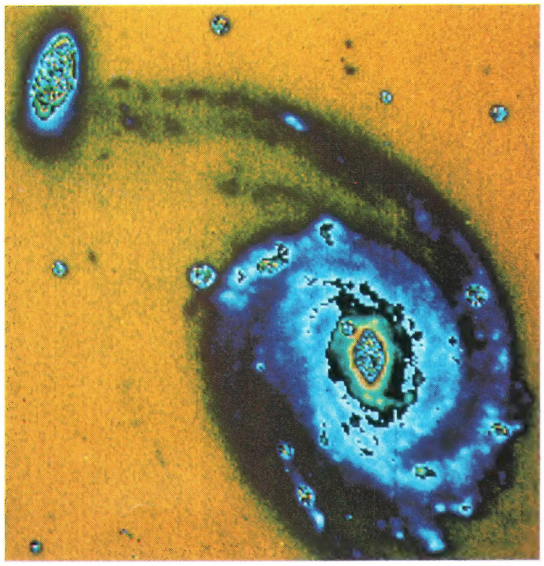
THE SOLAR SYSTEM



Mark Franklin

From edge to edge, the Milky Way measures 100,000 light years. Distances in space are measured in light years. This means, it would take a beam of light 100,000 years to travel from one edge of the galaxy to the other.

Light travels at 300,000 km/s – the fastest speed we know of – and a light year is the distance a beam of light would travel in that time.



Royal Greenwich Observatory SPL

***Two galaxies** in orbit around one another. The use of false colour shows clearly the larger, spiral galaxy and a smaller elliptical one. In the arms of the spiral galaxy are vast quantities of dust and gases, from which new stars are continually being formed. All the stars in a galaxy revolve around its centre. The Sun moves at 250 km/s, but it would take around 250 million years to complete an orbit.*

Since there are at least another 100 billion galaxies in the Universe, this gives some idea of the almost unimaginable scale of our ultimate place in space.

Baptism of fire

Third world out from the Sun at an average distance of 150 million km, Earth measures just 12,756 km across and has a solitary moon. It receives just enough light and heat to make it suitable for life. Except at the poles, and on high mountains, the temperature is such that liquid water can exist anywhere on the surface – a vital fact since it was in the oceans of the young Earth that life began.

Just after the Sun formed, about five billion years ago, it was surrounded by a great spinning pancake of gas and dust. Over the next few hundred million years, the loose material in this wide, rotating disc gradually lumped together to make the nine planets of the Solar System, along with a host of smaller objects like the various moons and asteroids.

Worlds, including the Earth, that formed fairly close to the Sun, built up mainly from rocks and metal. It was too warm for them to hold on to large amounts of lighter substances such as hydrogen and helium.

At first, the Earth may have glowed orange-red, like a bright coal fire. It was heated intensely, both by the break-up of radioactive elements inside, and also by meteors of every size that constantly bombarded it from space.

Slowly, the topmost layer of the Earth cooled and hardened to become a thin, solid crust. At the same time, hot, molten rocks from inside the planet continued to well up to the surface through numerous cracks and volcanoes. As they did so, this material set free gases, including water vapour, that gathered around the Earth as a primitive atmosphere – a protective blanket against space.

The emergence of life

At some stage, it seems that a thick 'soup' of chemicals steadily built up in the Earth's newly-formed ocean, from gases washed out of the atmosphere. Injected with energy by bolts of lightning and ultraviolet rays from the Sun, some of these chemicals became more and more complicated. Eventually, at least one of them started making copies of itself. From this amazing 'duplicating' substance, about three and a half billion years ago, the first living things developed.

Just amazing!

QUICK TRIP?

THE MILKY WAY IS UNLIKELY TO BECOME A POPULAR HOLIDAY DESTINATION. IF YOU DROVE A CAR FROM EARTH AT ABOUT 160 KM/H, IT WOULD TAKE ABOUT 221,000 MILLION YEARS TO REACH THE CENTRE OF THE MILKY WAY.

Paul Raymonde

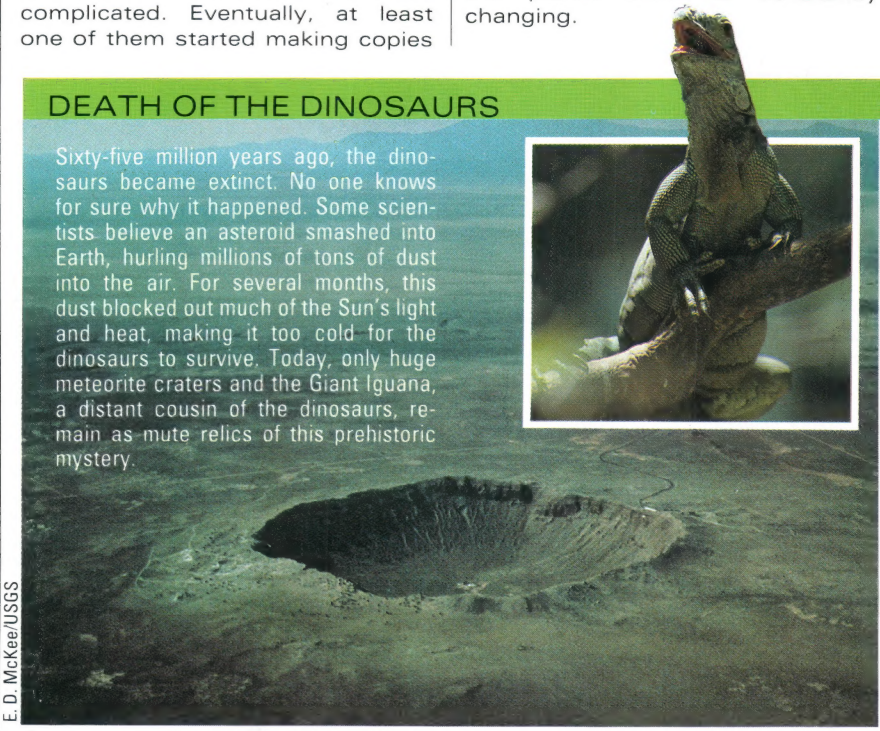
The dynamic Earth

Powerful forces have shaped the Earth – and those same forces are still at work in the world today. Wind and rain scour away rock, rivers carve valleys and canyons, and ocean waves pound against shorelines, eroding their shape all around the globe.

Yet even as old features on the surface are worn away, new ones slowly emerge to take their place. Mountain ranges are formed by these powerful forces, as are oceans and continents, which drift and change in appearance over millions of years. Slowly but surely, the planet Earth is constantly changing.

DEATH OF THE DINOSAURS

Sixty-five million years ago, the dinosaurs became extinct. No one knows for sure why it happened. Some scientists believe an asteroid smashed into Earth, hurling millions of tons of dust into the air. For several months, this dust blocked out much of the Sun's light and heat, making it too cold for the dinosaurs to survive. Today, only huge meteorite craters and the Giant Iguana, a distant cousin of the dinosaurs, remain as mute relics of this prehistoric mystery.



E. D. McKee/USGS

K. Wothe/Bruce Coleman Ltd.

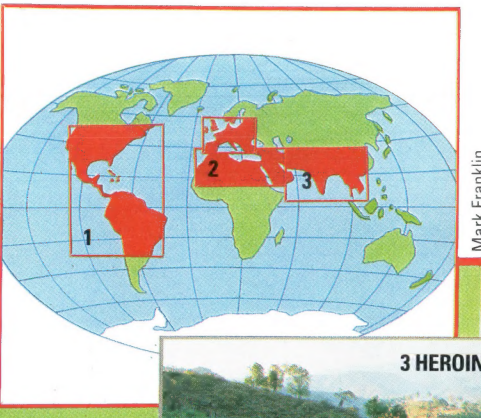
THE DRUGS MENACE

- ORIGINS
- THE HEROIN TRAIL
- THE 'DUTY MEN'

WALKING INTO THE CUSTOMS area of an international airport, a man suddenly keels over and dies. The cause of death – a lethal overdose of cocaine.

Swallowing small polythene bags of cocaine or heroin is just one of the extreme lengths drug smugglers go to in order to avoid detection by customs officers or police. The knowledge that a leak in just one of those bags could cause their death does not deter the drug carriers.

South America is the major producer of cocaine. In the hot dry areas of Peru, Bolivia and Colombia the leaves of the coca plant are



Mark Franklin

USA
Annual USA drug seizures in mid-1980s: tonnes
- cannabis: 7,800-9,200
- cocaine: 55-76
- heroin: 9.97

USA

The Bahamas and Miami are frequent stop-over points for northbound traffickers.

Mexico

Holland

UK

Germany

France

EUROPE

Spain

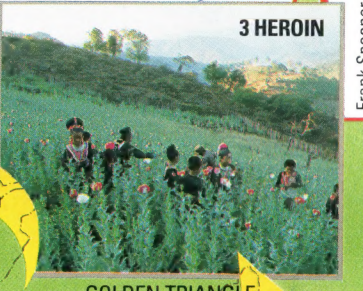
EUROPE
- Quantity of hard drugs seized risen five-fold in ten years.
- Drug addiction risen by 30% a year.
- Customs estimate they stop only ten per cent of drugs entering Europe.

GOLDEN CRESCENT

Iran

Afghanistan

Pakistan



Frank Spooner Pictures

GOLDEN TRIANGLE

Opium is treated with chemicals to become heroin. Its power as an analgesic is over ten times that of the original opium.

Burma

Laos

Thailand

Columbia

Peru

SOUTH AMERICA

Brazil

Bolivia

Between them, Peru and Bolivia are responsible for growing 90 per cent of the world's coca. Most of this will be turned into cocaine for export abroad.

Morocco

Algeria

AFRICA

Turkey

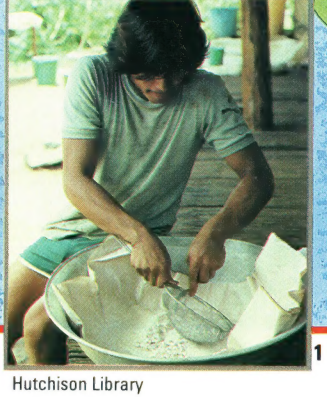
MIDDLE EAST

Saudi Arabia

Cannabis accounts for four-fifths of the total drugs seizures around the world.

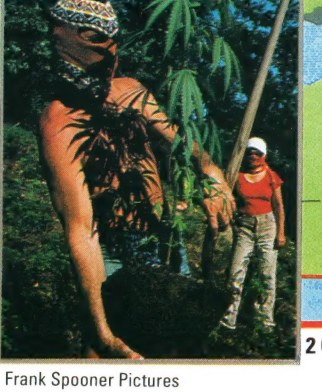
THE DEADLY TRAFFIC

Drugs are a global problem. Heroin comes mainly from the borders of Burma and Thailand – the so-called Golden Triangle – and the mountainous area between Afghanistan and Pakistan – known as the Golden Crescent. Cocaine comes mainly from Peru, Colombia and Bolivia. Without cocaine production, peasants who grow coca would starve. Cannabis is produced in Africa and the Middle East.



1 COCAINE

Hutchison Library



2 CANNABIS

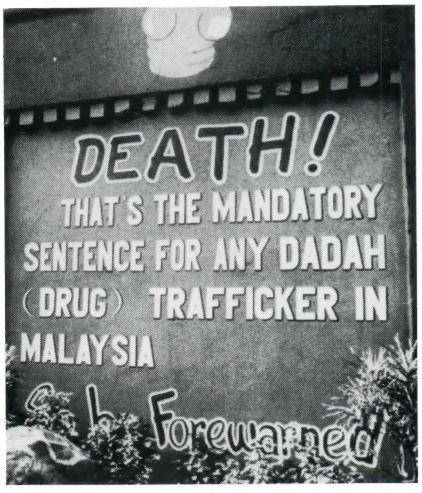
Frank Spooner Pictures

picked and processed in laboratories hidden in the jungle. Each coca leaf contains roughly one per cent cocaine. When the leaves are treated with chemicals they form a paste and, eventually, a fine white powder. The cocaine is exported around the world, to be used as it is or to be refined a stage further. Using a heat source and baking powder, a higher degree of purity is extracted from the cocaine to produce the drug known as 'crack'.

The hemp plant from which cannabis is made, also thrives in South America as well as in Northern Africa, where it is produced for smuggling abroad. The plant is related to nettles and hops. Tetrahydrocannabinol, a mild hallucinogen, is found in all parts of the hemp plant except the seed.

Resin is found in the tips of the shoots and flowers, and is scraped off and sold as hashish. The whole plant can be pressed into blocks to produce marijuana.

Dadah spells death *in Malaysia – as the writing on the wall of a Kuala Lumpur prison warns. Inside drug users and smugglers await execution.*



Associated Press

Heroin is derived from the opium poppy. Below the petals of the poppy flower is a seed pod that produces a juice, which is harvested as opium. Despite frequent raids to destroy the crops, farmers in the main opium growing areas are unwilling to relinquish the poppy. On average, they earn 30 times more from poppy production than they would from wheat.

The raw opium is transported to processing centres where it is converted into heroin. Since heroin is light, compact and easy to hide, smugglers have little trouble in transporting it to the big cities and from there to international airports.

A more recent arrival on the drugs scene is a tablet called Ecstasy. This is a synthetic drug made up from amphetamine powder by a chemist. Either the tablets are processed in secret laboratories abroad and smuggled in, or the powder itself is imported and made into Ecstasy tablets here.

Busting the barons

Drug smuggling has become big business. The men who operate smuggling rings – the drug barons – are so rich and powerful they are rarely caught. They pay others to take risks for them, and corruption and murder have become a way of life. Even their own employees are terrorized. In 1985, 40 workers in Peru were massacred because they refused to obey orders.

Big smuggling operations can involve hundreds of people in several different countries. In the UK, the National Drugs Intelligence Unit is staffed by police officers and by Customs and Excise.

Trained sniffer dogs *are now a vital part of Southern US police forces, as they try to stem the massive tide of drugs entering from South American countries such as Colombia.*

Rob Nelson/Picture Group/Colorific

Just amazing!

CASTOR OIL KILLER

RICIN, MADE FROM THE CASTOR OIL PLANT, IS ONE OF THE MOST TOXIC SUBSTANCES KNOWN TO MAN. JUST ONE FIFTY-THOUSANDTH OF A GRAMME IS FATAL – AN AMOUNT INVISIBLE TO THE HUMAN EYE.

Paul Raymonde

The police may keep a suspect under surveillance for months at a time, recording his or her actions on concealed cameras. When the suspect travels abroad, his or her suitcase may be marked with an ink visible only under ultraviolet light. On return to the UK, the case will be pulled out and a sniffer dog set loose on it to seek out any narcotics.

On the alert

Officers are aware of most of the usual – and unusual – hiding places, – inside bottles, statues, secret compartments in luggage, in food and even alongside dead bodies coming home for burial. These officers are quick to notice any containers that have been tampered with – new seams, traces of glue – or that are too heavy or too light to be carrying their usual contents.

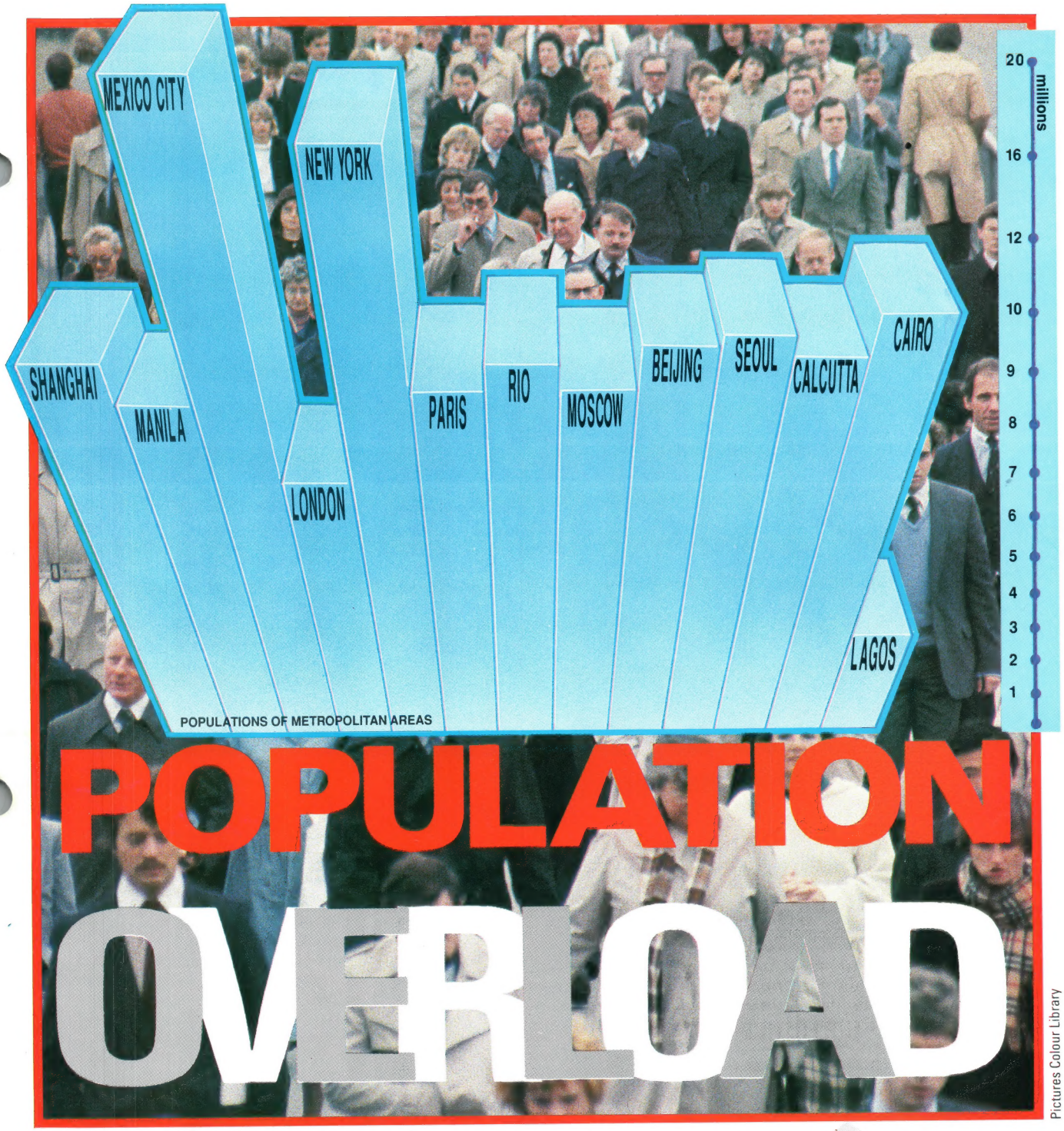
One officer was alerted when a chess set, apparently made of onyx, was easily scratched. When handled, the items had a waxy feel. It turned out that each piece had been moulded from 90 per cent pure cocaine paste.

At ferry ports, a suspect car may well be stripped apart before any drugs are found. Cannabis from Northern Africa is often brought up through Spain and France, concealed in the petrol tank of a car. A spectroscope, based on fibre optics, enables officers to peer round corners inside the tank.

Looking to the future

The number of drug seizures by police and customs increased several times over in the late 1980s. Unfortunately, so too has the quantity that reaches the street.

Police enforcement alone is not enough to solve the drugs problem. Individual communities must face up to the dangers of drug abuse. In the end the solution relies upon a society in which everyone says 'No' to drugs.



POPULATION OVERLOAD

Pictures Colour Library

THE DENSEST CITIES

RURAL MIGRATION

SHANTY TOWNS

ONE BABY IS BORN somewhere in the world each second. Even allowing for the death rate, this adds millions to the global population each year. In 1987, it passed 5 billion, and by the middle of the next century, it is expected to have doubled.

China is the first country in the world where the population has topped the one billion mark. This has led to a state-controlled policy of one child per couple. India has the world's second largest population – more than 700 million people.

But in many Western nations, the rise in population has started to level off. Even so, cities throughout Europe and North America are affected by serious overcrowding problems.

Unemployment, poverty and crime in grim ghettos, where buildings have been allowed to fall apart, contrast starkly with the luxurious lifestyles of the wealthier districts.

In developing nations, the problems are in danger of becoming insurmountable. Large numbers of rural dwellers migrate to the industrial centres in search of work. The result is an almost uncontrollable growth of the cities.

***Mexico City,** with nearly 20 million people (in the diagram) – and a UN projection of 31 million by the year 2000 – weighs in as the globe's most populous city.*

Already, overcrowded cities, such as Bombay and Mexico City, are straining to cope with the influx of men, women and children arriving from the surrounding countryside in search of work.

Crumbling cities

By the year 2025, the cities of the Third World will be home to four billion people – four times the level of the mid 1980s. Even now, cities such as São Paulo in Brazil have traffic jams that last throughout the 12 hours of the working day, adding

dense exhaust fumes to the already polluted atmosphere.

As the quality of urban life declines, those people who can afford to, move out of the city. London, for instance has lost a fifth of its population over the last 40 years.

Small rural villages that once were well away from the fringes of the city grew as the demand for housing in them increased. In time, some may become mere suburbs of a sprawling urban area, or 'dormitory' towns, whose inhabitants commute to the city for work.

Shanty towns

Meanwhile, in the inner cities, old housing is often left to decay. Many run-down terraces were demolished in the 1960s to make way for tower blocks. But, untended, they too quickly became slums.

For the young people who have grown in the restrictive poverty of a rural village, the big cities are like a liberating magnet. They offer the chance of a job, a higher standard of living, and such luxuries as electricity, piped water and shops.

But the newcomers often have no money with which to buy or rent a home. The alternative is to sleep on the pavement or build their own simple shelter on the outskirts of the city. This is how shanty towns have developed.

A shanty is a home constructed of any waste material – corrugated iron, empty oil drums, pieces of timber, or even cardboard. Gradually, a large community of shanties spreads out in a jumbled mass around the city.

With no fresh water supply or sewage system, the shanty town is a breeding ground for disease. Some city authorities, acknowledging the city's dependence on the workers from the shanty towns, are at least trying to help the destitute dwellers by supplying some basic amenities. Fresh water is piped into new areas where settlers arrive. Banks of building materials and advice centres are also set up so that people can make better and safer homes for themselves.

Gamma/Frank Spooner Pictures

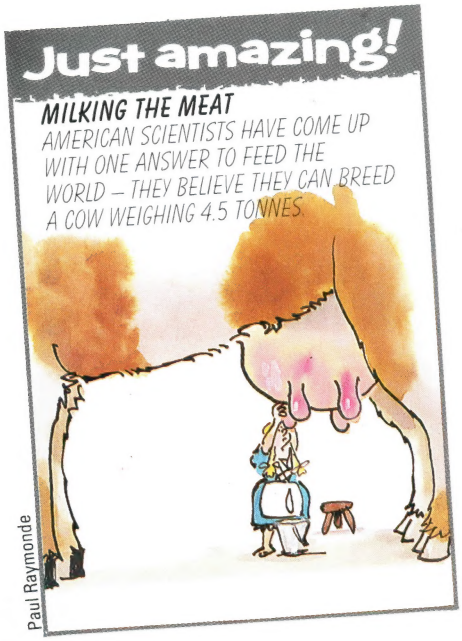
***Irrigation projects** in developing countries make once barren land arable. This provides work and food for people who would otherwise pour into already overcrowded cities.*

Sally & Richard Greenhill

China has a growth rate of one and a half per cent each year, and, with a total of over a billion people, is the most populous country in the world. A strict birth control programme is in force restricting each couple to one child only. However, centuries old traditions mean that female babies are not very welcome. To avert a tragic fate, posters advertise the pleasure of having a girl child.

Rex Features

***Shanty dwellers** on the outskirts of prosperous cities live in the most basic shelters and make the best of what comes to hand.*



Paul Raymonde

FOUR BILLION YEARS BC

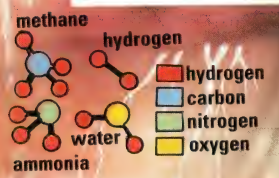
ONE SINGLE MICROSCOPIC living cell, less than a thousandth of a millimetre across, is the ancestor of all life on Earth, from the minutest plant forms, living as green scum on the surface of water, to the largest whales in the depths of the oceans.

This first live forebear of all living things, including Man himself, was formed by chance, probably over 3,500 million years ago.

Scientists have shown that the building blocks of life — carbon-containing organic molecules — existed on Earth, and in space, soon after the planet's formation 4,600 million years ago. They were in the gases that made up Earth's atmosphere, in the outpourings of volcanic eruptions, in the meteorites that pounded the young planet — and even in the dust of space itself.

Zefa

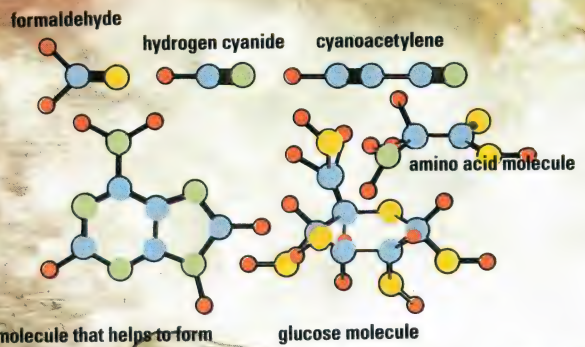
Frank Kennard

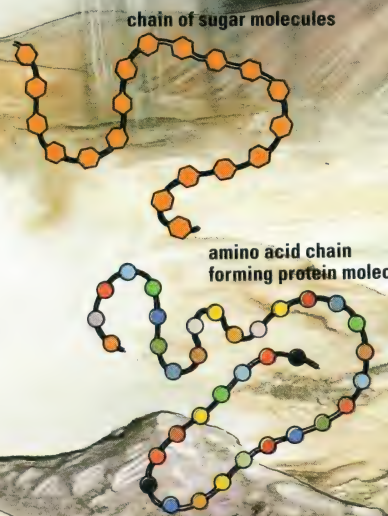


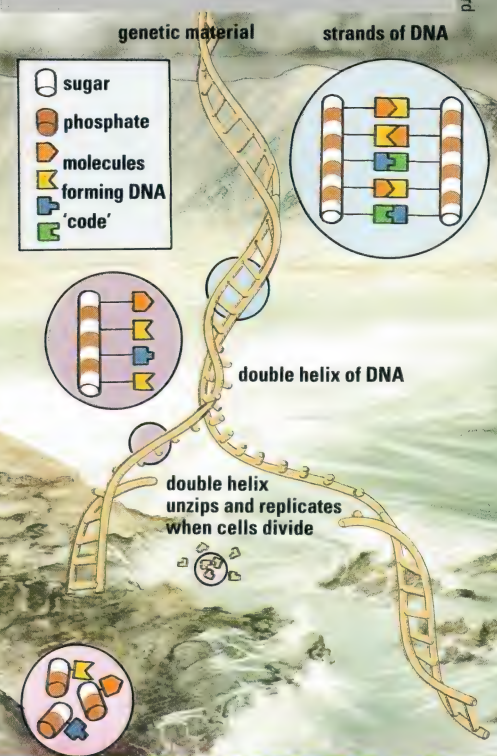
1. GASES IN EARLY ATMOSPHERE
Before life appeared on Earth, the atmosphere contained lots of simple chemicals such as methane, hydrogen, ammonia and water.

2. THE PRIMEVAL SOUP
Sunlight and lightning caused these chemicals to react together and form larger molecules that collected in the oceans of the young Earth.

3. THE FIRST STEPS TOWARDS LIFE
More chemical reactions took place in the ocean. Sugar molecules joined together in chains to form starches and cellulose. Even more important, simple amino acids joined together to form simple proteins. The biggest step of all occurred when sugars and nitrogen compounds joined together to form DNA, the structure that transmits information from one generation to the next.



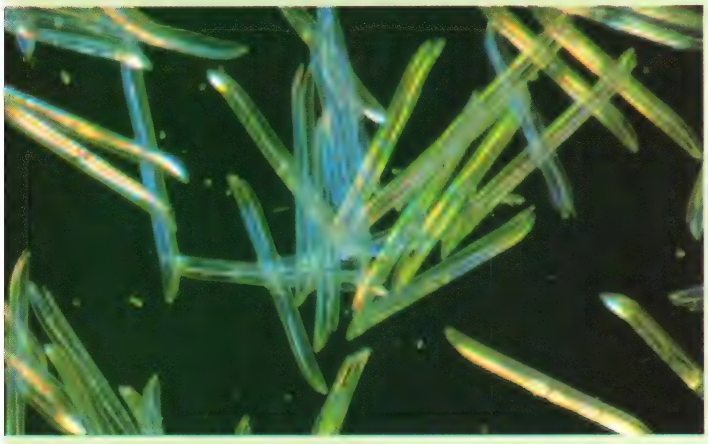




Space probes by the US and the former Soviet Union have confirmed that carbon molecules exist in the icy bodies and tails of comets, such as Halley's comet, which periodically pass close to Earth. Astronomers have identified 75 different interstellar complex molecules that have come into being in the star-forming clouds of space.

Living cells need protein molecules to form their structure, and DNA (deoxyribonucleic acid) molecules to hold information on how to develop. Both proteins and DNA are formed from other molecules, called amino acids and bases. These consist of even simpler molecules.

The odds against the correct combinations coming together by chance are enormous. Yet somehow, within the Earth's first five thousand million years, they did.



Peter Parks Oxford Scientific Films

Fossilized micro-organisms *were discovered locked into the 3,800 million year-old Isua rocks of Greenland. Scientists have also discovered colonies of fossilized blue-green algae cells in the Warrawoona rocks of Western Australia. Using electron microscopes and radiometric techniques, they have dated these to 3,500 million years.*

Lightning bolts from electrical storms bombarded the Earth and its watery surface, where shallow pools lay rich with organic molecules – a warm soup of potential life. Massive doses of ultraviolet radiation from the sun poured down into the atmosphere and on to the surface, as yet unprotected by oxygen and an ozone layer. Great numbers of meteorites – some probably containing complex molecules such as amino acids – pierced the unresisting atmosphere and plummeted to Earth. Lava and hot gases poured out of volcanic fissures and spewed violently forth from eruptions, creating hot-spots in the atmosphere, and adding more gases to its composition.

Single cell life

Triggered by the energy from these violent natural events, the molecules in the primeval soup joined up to form complex chains. So a few hundred million years after the Earth's formation, all the components of living cells were present in the ocean and it was only a matter of time before they were organized into cells. These came into being when various fats and proteins joined together to form an outer membrane. This separated the contents of the cell from the water it floated in.

For over 2,000 million years, cells remained tiny and primitive, each one hardly a thousandth of a millimetre in diameter. The first living cell split into two, each containing the DNA information necessary for further development. Two became four, and four became eight. Eventually those cells lived in teeming accumulations, millions to the cubic centimetre.

Cell mutations

As these cells reproduced, slight changes or mutations occurred in them. Sometimes these chance mutations were favourable and they helped the cell survive, often in conditions different from those in which the parent cell lived. Some cells eventually mutated into a life form that contained chlorophyll, the substance that makes plants green. With the assistance of chlorophyll, these cells started to make sugars using the energy of sunlight.

The sunlight-using cells needed hydrogen for energy conversion. They obtained it by splitting water molecules into their separate hydrogren and oxygen components. The cells used the hydrogen and released the oxygen as waste. Great matted masses of these oxygen-releasing cells lived in warm, shallow seas. After hundreds of millions of years, oxygen built up into a significant ingredient in the Earth's atmosphere.

A new type of cell began to develop about 1,400 million years ago. Dependent on oxygen, this new cell was larger and much more complex. It had a special nucleus for its DNA, and had at least a thousand times as much as earlier, more primitive cells. Called a eukaryote, which means true nucleus, the new cell developed the ability to join up with other cells and share genetic information, so that their offspring had a much larger fund of genetic possibilities.

Eukaryotes also became capable of forming multi-celled organisms, in which the individual cells have particular tasks. Nearly all life in today's world is formed of eukaryote cells. The first fossils of multicellular life forms are 750 million years old.

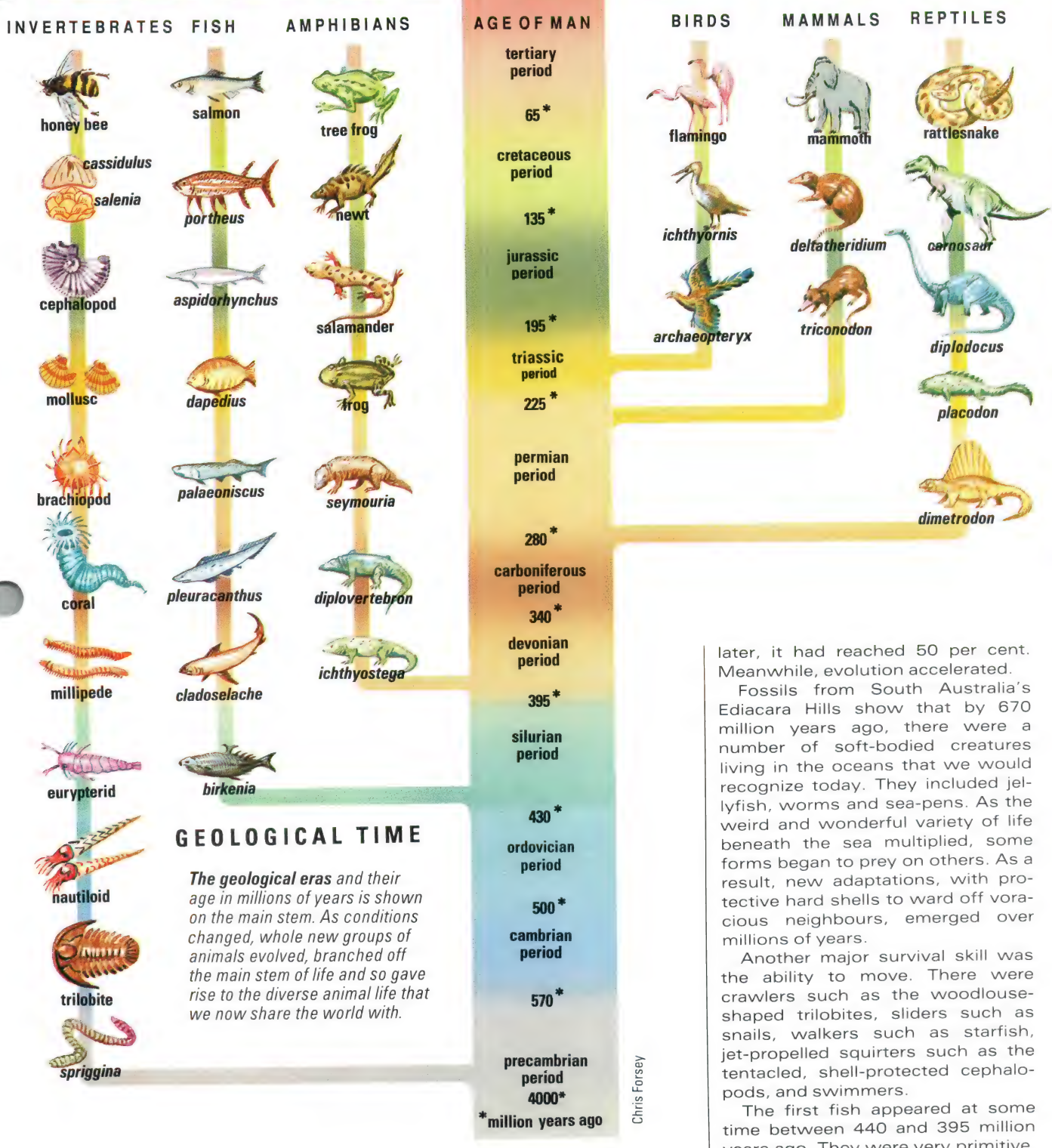
Paul Raymonde

DNA – CREATING LIFE

Sio Photo

The scientific world ridiculed the first researchers who claimed that life sprung from organic compounds created when ultraviolet radiation or lightning struck the Earth's atmosphere. Then an American, Stanley Miller, proved the theory correct. He directed electrical charges through a mixture of methane and ammonia gases. Inside a week he had produced a tar-like ooze containing amino acids and other organic molecules. Later experiments, with ultraviolet light, heat, and even sonic booms, in a variety of gas mixtures, had similar results. Nearly all the amino acids and DNA bases necessary for cell life have been created in experiments mimicking conditions on the primeval planet.

SMALL BEGINNINGS



GEOLOGICAL TIME

The geological eras *and their age in millions of years is shown on the main stem. As conditions changed, whole new groups of animals evolved, branched off the main stem of life and so gave rise to the diverse animal life that we now share the world with.*

IN THE LONG, SLOW HISTORY of life's development on Earth, Man is so recent as to seem a mere footnote.

If the history of the world were a feature film, Man would make an appearance just as the words 'The End' were appearing on screen.

From about 4 billion years ago, microscopic, primitive single cells, called prokaryotes, held sway in the Earth's oceans. Larger, more complex eukaryotes began to appear 1.45 billion years ago as the oxygen level of the atmosphere built up. One billion years ago, the oxygen level was around six per cent of what it is now: 400 million years later, it had reached 50 per cent. Meanwhile, evolution accelerated.

Fossils from South Australia's Ediacara Hills show that by 670 million years ago, there were a number of soft-bodied creatures living in the oceans that we would recognize today. They included jellyfish, worms and sea-pens. As the weird and wonderful variety of life beneath the sea multiplied, some forms began to prey on others. As a result, new adaptations, with protective hard shells to ward off voracious neighbours, emerged over millions of years.

Another major survival skill was the ability to move. There were crawlers such as the woodlouse-shaped trilobites, sliders such as snails, walkers such as starfish, jet-propelled squirters such as the tentacled, shell-protected cephalopods, and swimmers.

The first fish appeared at some time between 440 and 395 million years ago. They were very primitive, jawless creatures that nosed, heavy-headed, along the sea-bed. They were also the first creatures with real backbones.

When fierce predatory fish with proper jaws and teeth evolved in the next 50 or 60 million years, they devoured the jawless fish, though some remain as lampreys.

Robert Harding Picture Library

The most advanced *of species, Man has had to adapt to survive in his environment. Bushmen in the African desert, where food and drink is scarce, can smell out water. The skin over their stomachs can expand so that they can eat several days' worth of food at a time when they finally make a kill. They are said to communicate telepathically.*

REDISCOVERED PREHISTORIC FISH

J. L. Geraud/Gamma/Frank Spooner Pictures

The coelacanth, a fish that preceded the amphibians, dates back almost 400 million years. Scientists believed it had been extinct for about 60 million years. But in 1938, a coelacanth was found in the Indian Ocean. Modern coelacanths live 200 metres underwater, where lack of enemies and a slow metabolism have allowed them to survive pretty much unchanged.

The backboned killers flourished, growing in some cases to huge sizes, ten metres and more in length.

With increased oxygen came the first land-life: plants at first, algae, then reeds, then bushes and trees. 345 million years ago, tall, scaly plants covered land surfaces in the first forests. They were the habitat of insects that evolved from spineless sea-life.

As periods of drought dried up seas and lakes, some fish developed the ability to gulp air above the water. Lobe-finned fish evolved the skill of walking from pool to pool. They eventually became the first amphibians, equally at home in water or on land.

The age of plants lasted 75 million years, laying down the fossil-beds that are today's coalfields. Reptiles, evolving from amphibians, stayed permanently on land. Flying insects developed, including giant dragon-flies, and the cockroaches that have hardly changed in the 300 million years till today.

The first mammals

Closer to our own era, the speed of the multiplication of life forms increased, as the huge pool of genetic information increased with each cell division. The dinosaurs ruled for over 200 million years. In that time, birds emerged and so did warm-blooded mammals – the next inheritors of the Earth.

Then as the dinosaurs vanished perhaps as the climate became too cold for them. Dust from a meteorite bombardment may have shielded the Earth from the sun's rays.

From the sudden extinction of the dinosaurs 65 million years ago, the great diversity of mammal life – from tiny shrews to huge elephant-like mastodons – colonized the planet. Each species was subject to its environment and the pressures of finding food, escaping predators, and successfully multiplying.

Some remain almost unchanged after millions of years, others fell victims to the relentless logic of 'adapt or die'. It has been calculated that 99.999 per cent of all the life forms that have ever existed are now extinct. Yet today, Man shares the planet with up to ten million other species.

Just amazing!

LITTLE AND LARGE

TO GROW BIG AND STRONG, IT HELPS IF YOU EAT YOUR BROTHER OR SISTER, IT SEEMS. EXPERIMENTS SHOW THAT CANNIBALISTIC TADPOLES THAT PREY ON OTHERS GROW INTO MUCH LARGER FROGS THAN THEIR BROTHERS AND SISTERS.

Paul Raymonde

SUPER SURVIVOR

Oxford Scientific Films

One of the world's greatest success stories, cockroaches have existed since 320 million years ago. There are 3,500 known species, ranging from a minute cockroach that rides queen ants, to the ten centimetres long *Blaberus giganteus* of South America. Some cockroaches can live for three months without food and a month without water, others can survive being frozen for two days. They are more resistant to nuclear radiation than humans, and so would be among the survivors of a nuclear war.

TRAINED TO SURVIVE

Aerospace Publishing

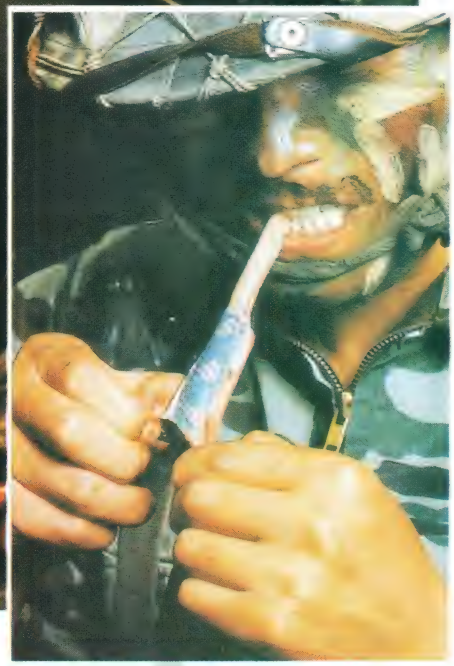


Photo Press International

Squeamishness soon disappears when hunger sets in – a snake makes a nutritious meal, but needs to be skinned before eating.

- HUNTING FOR FOOD
- SOURCES OF WATER
- ADRIFT AT SEA

IN PRIMITIVE TIMES, EVERY day was a battle for survival as people had to find their own water, food and shelter. Nowadays, we can buy everything we need and the skills necessary for survival are largely redundant.

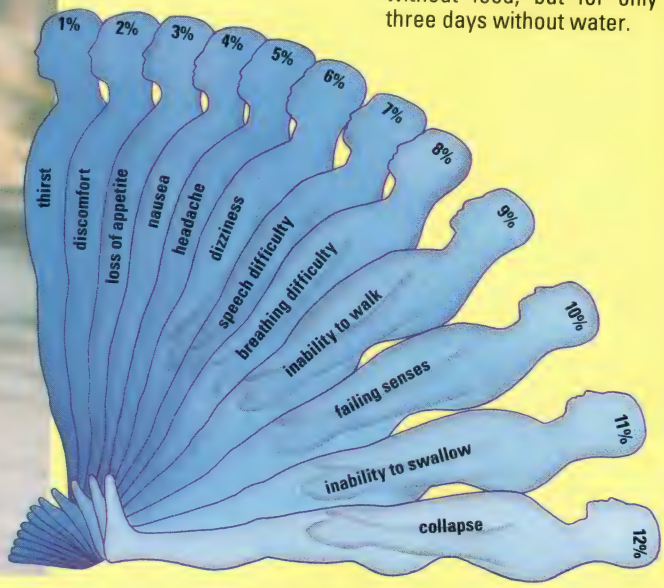
The only group of people who are still trained to survive in the wild are soldiers – and they are usually equipped with ration packs for most eventualities. The pack is designed for one or two men and provides a limited balanced diet for combat conditions. The General Service single-man pack weighs 2kg and is rich in proteins and carbohydrates for stamina and energy. As well as main meals, there is also a variety of chocolate and sweets to be snacked on outside mealtimes, when on the move or when they are resting up.

BASIC SURVIVAL RATIONS

Aerospace Publishing

Army issue survival packs include protein in the form of tins of bacon-grill or bacon burgers, various meat spreads and main meal items such as chicken curry, steak and kidney pudding and minced steak. Carbohydrates include instant porridge, pre-cooked rice and 'heavy' biscuits. Spaghetti and beans provide extra energy. The packs also contain a wide variety of powdered drinks and a selection of chocolate and sweets for use as snacks. A small solid fuel stove is included.

Prolonged, strenuous exercise, such as cycling, can cause dehydration. If this occurs, the victim suffers worsening symptoms with every one per cent body weight loss, until he or she finally lapses into unconsciousness. Water is essential for survival – a person can survive for three weeks without food, but for only three days without water.



Mark Franklin

Image Bank

The rations in the pack provide plenty of fuel for a period of combat activity, but are severely lacking in fresh produce and can induce constipation after a few days.

The pack comes complete with a small solid fuel stove to heat up the food and to make hot drinks which are essential in cold or damp weather. Powdered coffee, hot chocolate drink, orange, milk and tea bags, plus a meat stock cube and an instant soup provide the incentive to take plenty of liquids: up to one gallon per man daily.

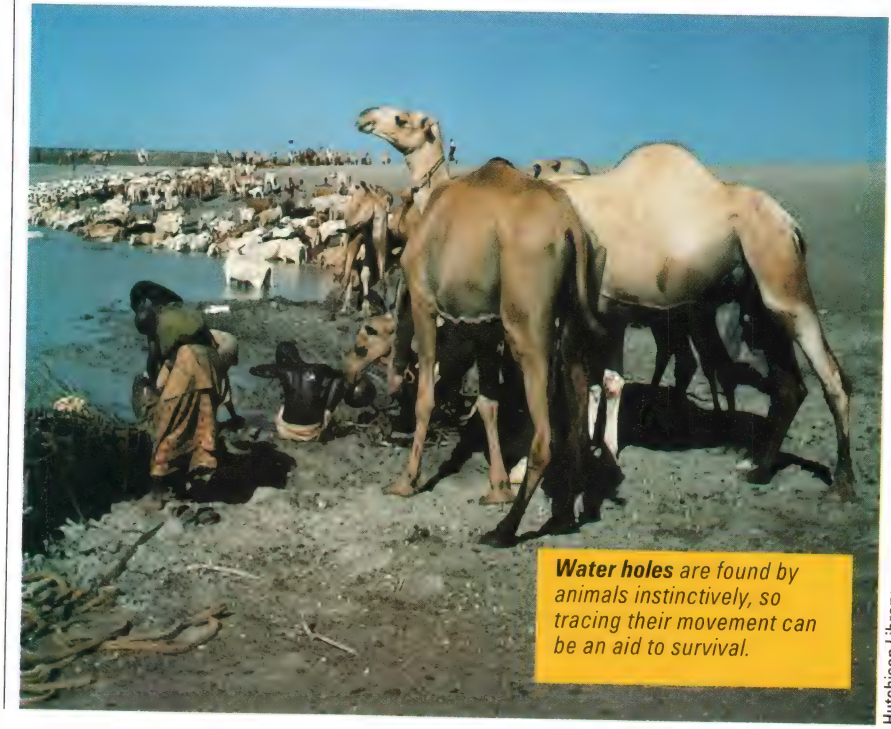
Water loss

Out in the open, carrying heavy loads, travelling fast and far, often over difficult terrain, the soldier on combat duty is very vulnerable to dehydration if he neglects to keep his liquid intake up. Around 60 per cent of the average body weight comprises water and an individual can afford to lose, temporarily, up to ten percent of this – about six percent of their total body weight – but any loss must be made up, for the effects of dehydration can be very debilitating.

Losing up to two percent of body weight leads to discomfort, with a sticky mouth and tongue, and maybe dry lips. At three percent appetite disappears and at four percent the victim begins to feel intermittent waves of nausea. By this time the dehydrating soldier is in serious need of a drink. Headache and dizziness may accompany further weight loss and by the time seven percent weight loss has occurred, he will experience difficulty in talking. Non-commissioned officers (NCOs) accompanying soldiers under training shoot questions at the soldiers when they start showing signs of dehydration, listening out for incoherence, slurred words and other speech problems.

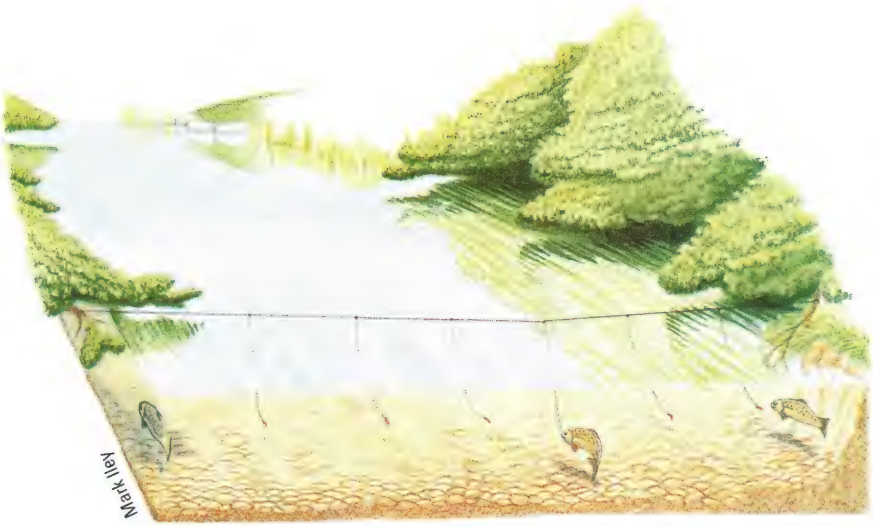
From here on, the dehydration is beginning to severely disable the victim. With eight percent body weight lost, a person begins to have breathing difficulties; at nine percent down, his legs start to give out and he may walk like a drunk, with rubbery legs and little sense of direction. Sometimes soldiers on route marches will stride erratically straight into a hedge or ditch at the side of the road. With ten percent weight loss, eyesight and hearing become impaired. At 11 percent loss the sufferer is in great distress and unable to swallow, as his tongue and throat swell up. At 12 percent weight loss, he collapses.

Soldiers in training are pulled out of an exercise and restored with rest and liquids long before this stage is reached. People in real



***Water holes** are found by animals instinctively, so tracing their movement can be an aid to survival.*

Hutchison Library



Mark Iley

A static fishing line *can be better left unattended. To set up, stretch a piece of cord between two stakes above the surface of the water. Attach several shorter lines to this, each equipped with a baited hook. This is a useful technique when fighting for survival, but under normal circumstance fixed lines are illegal in the UK.*

Spearing fish *is another useful fishing technique – a tree branch carved to a sharp point makes an ideal weapon.*

emergencies may not be so lucky. Long before collapse, they are incapable of actually seeking out water, so even the early stages of dehydration represent a warning that would be suicidal to ignore.

Survival in the wild

Once the ration packs have given out, the soldier, or indeed anyone lost or caught out in the wild, has to become a hunter gatherer like his ancestors many thousands of years ago. In temperate climates, the game can consist of rabbits and hares, a large variety of birds (and their eggs), mice, rats, squirrels, snakes and fish. If a soldier is prepared, he may be carrying wire snares, fishing hooks and line, or even a catapult. All of these can be improvized if necessary. If he is in a particular region for any length of time he can carefully survey it for regular animal tracks, note where birds perch or nest for the night and spy out where big fish lie against the stream bank, or in the shadow of a rock.

Simple spears are easy to make using a knife. If the end of the spear is split and the gap held open with a small wedge, then both sides can be sharpened and carved to have rough barbs which will provide an efficient fishing spear. During the day, the hunter must stand in the water with the spear poised and thrust below where the fish seems to be – this is difficult as refraction of light through water distorts the image. At night a blazing torch – birch bark makes a good, long burning torch – can be used to attract fish for spearing.

Without food rations, *climbers could not survive. Melted snow would provide water, but finding food would be almost impossible on mountain sides.*

Paul Henley/Tropix

Slugs and snails *may not appear to be appetizing, but in Australia witchety grubs are eaten by Aborigines as a matter of course.*

Hutchison Library

Animal snares must be set up where animals regularly pass. Tracks, worn grass and wisps of fur give their runs away. A simple loop-snare may do the trick, but it is better if attached to a spring in the form of a bent-over, resilient branch, held lightly in place by a notch in a firm stake. The impetus of the animal hitting the snare frees the bent branch, which springs straight, tightening the noose.

Chris Bonington/Bruce Coleman Limited

Cooking the catch

Caught game, animal, fish or bird, needs to be gutted. The guts can be retained as bait, although the liver and heart can be eaten. Once hunger has taken over, flesh can be eaten raw. Alternatively, small game, fish and birds can be cooked over a fire on an improvized spit. It is better to do this over glowing embers rather than over flames.

Plant food can be found from the Arctic to the equator, with the exception of some arid desert regions. With plants, especially mushrooms and other fungi, recognition is essential as many are inedible, poisonous or deadly. If in doubt, do not eat. In the Arctic mosses and lichens are nutritious, and in coastal regions some seaweeds are an excellent form of food.

Water sources

Anyone who has to survive in the wilderness soon learns to find water in low-lying ground, in the hollows of trees and in seepages from cliff bases. Also watching animals or listening for signs such as croaking frogs, can pinpoint potential water sources. Dew can be collected by sponging it up from long grass and shrubs with an item of absorbent clothing and carefully wringing it out into a container.

Desert survival requires both shelter and a source of water. Cactuses and roots are possible sources, but a solar still is an efficient way to distil water out of the ground. A hole of one metre across and 50cm deep can be dug out and a container placed in the bottom. If the hole is covered with a piece of plastic sheeting, large enough to form a cone-shape when weighted in the centre with a pebble, and secured with rocks around the edges, the heat of the day will produce water vapour from the trapped air and the earth beneath it. This will condense on the underside of the plastic and run down to drip into the container. A still can produce over half a litre every 24 hours. If enough plastic is available, a series of stills is the best method of producing a vital amount of water.

***Solar stills** are often part of life raft equipment. These work by condensing sea water and collecting the condensation.*

Avon Inflatables

MAKE AN EARTH OVEN

Larger items of food can be cooked in an earth oven. Dig a hole 50 cm deep and 25 cm across. Heat several small boulders in a fire for at least one hour and drop them into the hole. Drive a stake into the centre of the hole and surround it with loose earth, placed on top of the boulders. Follow with a layer of green vegetation, such as grasses. A skinned animal or large joint from a deer or a pig can now be placed on top, followed by another layer of vegetation, then another layer of earth. The hole should be almost filled. The stake should then be pulled out and the resulting hole filled with about one litre of water. The whole oven should immediately be capped with a large rock and any gaps sealed with earth. This oven will act like a pressure cooker and the meat will be fully cooked in a couple of hours.

FOOD FROM THE SEA

Seaweeds are a good source of protein and minerals – in Wales they are used to make laver bread. Seaweeds are not poisonous, but some types contain a type of acid which can irritate the digestive tract. To check, crush the weed well between your fingers, then leave it for five minutes – if it does contain the acid it will give off an unpleasant smell.

Lythgoe/Planet Earth Pictures

Survival at sea

Some people have managed to survive for months at sea in open boats or life-rafts, living on whatever water and food they could get from their immediate environment. Some have lived on the turtles and fish attracted to the shade of their vessel, catching the turtles with a simple rope noose, and baiting homemade hooks with lures of rag (or pieces of turtle) to catch fish. With minimum exertion, and some form of shading canopy, survival on less than one litre of water a day is possible.

A day without water closes the kidneys down to a certain extent and supplies can then be rationed to about 400ml per day for the next three days. A strict regime of up to a quarter of a litre per day, if available, can then be followed. Apart from rain water caught in sails or cloths, some life-rafts have solar stills. Fish can also be a source of water – watery fluid can be found along the spinal bone of some large fish and the eyeballs are also a good source of drinkable liquid. Some sea survivors have obtained nutriment from seabirds, grabbed when they land on the boat. Another food source is seaweed, which can be snagged with a home-made grappling iron dragged behind the vessel.

Squeamishness soon disappears with hunger and thirst. British Marines and Paratroopers are taught the protein value of the worm omelette early in training. Earth-worms, snails, grubs and slugs are all good sources of protein. They can be dried out in the sun and added to stews, or mixed with scrambled birds' eggs.

Paul Raymonde

- SCALING HEIGHTS
- PLUMBING DEPTHS
- NATURAL HAZARDS

MAN AGAINST NATURE

Dave Pace/DMM International

THE EXPOSURE TO DANGER, the elements or hostile terrain, the confrontation with nature at its most savage and the sense of achievement after completing a difficult climb or a journey into the bowels of the earth give many of the more dangerous sports their main attraction.

Strenous exertion *at high altitudes brings about an increase in a climber's breathing rate and blood flow.*

Underground caverns *are excavated by millions of years of water seepage.*

What goes up *must come down, and a climber encounters just as many hazards when he or she makes the return journey.*

Allsport/Vandystadt

Ian Smith/Troll

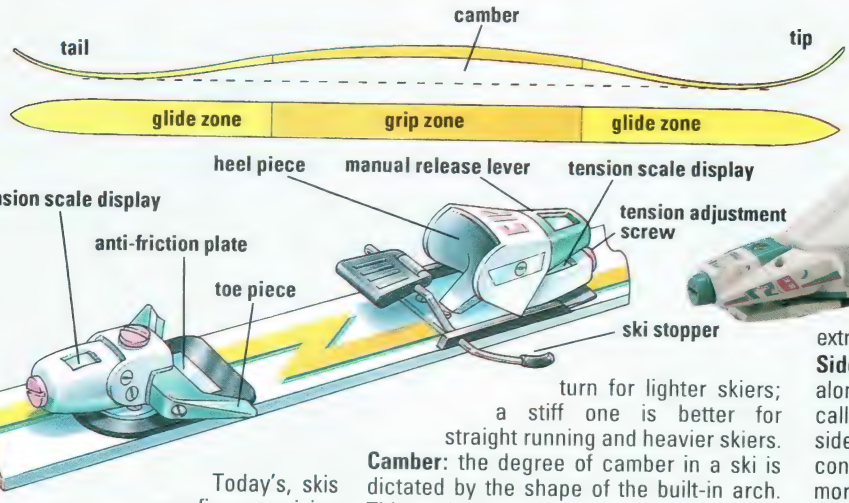
Despite the dangers inherent in sports such as mountaineering and potholing and the fact that most of the highest mountains or deepest potholes have already been conquered, the urge to compete against nature remains as vital as ever.

Mountaineering

Climbing mountains is a supreme test of physical and emotional fitness. For not only do mountaineers need the strength to literally pull themselves up mountains and the nerve to cling to sheer rock faces supported only by a small steel piton, they also need to cope with the greater problems of surviving high altitudes without using oxygen cylinders.

As altitude increases, air pressure decreases and there is less oxygen to breathe. This lack of oxygen causes changes in processes within

ANATOMY OF A SKI



Chris Lyon

Salomon/Ian Mackenzie

Today's, skis are fine precision tools specifically designed to meet the demands of the different types of competition.

Flexibility: a range of flexibility can be achieved with modern composite materials such as fibreglass. A pliable ski is easier to turn for lighter skiers; a stiff one is better for straight running and heavier skiers.

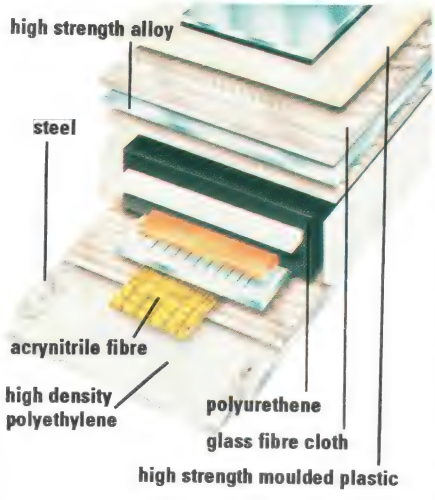
Camber: the degree of camber in a ski is dictated by the shape of the built-in arch. This arch allows the skier's weight to be distributed along the whole length of the ski. The camber also provides a springboard effect which helps to lift the skis for turning. Too much camber makes turning hard work; too little leads to the extremities not getting a grip and sticking.

Sidecut: most skis are waisted – narrow along the length. The degree of waisting is called sidecut. When the ski is laid on its side by knee movement, the tip of a ski with considerable sidecut will bite and turn more than that of a non-waisted ski.

Bindings: ski bindings are designed to clamp the boot firmly on to the ski, but to release the skis if the skier falls.

Boot: all boots have a rigid plastic outer shell that is angled forward, plus a hinge at the ankle to allow forward movement.

Ski components *are bonded together in a mould under high pressure and heat.*



Rossignol

the body which can lead to major medical problems if the body does not adapt to them and the person remains at high altitude for too long.

As there is little stored oxygen in the body, man is dependent on an elaborate and highly integrated series of mechanisms to transfer oxygen from the air to individual cells. Each link in the oxygen transport chain undergoes some modification on exposure to altitude, beginning almost immediately.

Breathing increases, carbon dioxide is lost and the pressure of oxygen increases in the alveoli – the tiny pockets of lung tissue which transfer oxygen from the air to the blood. This increased pressure enables oxygen to pass into the capillary network within the lungs more efficiently.

The diffusing capacity of the lungs – the ability to disperse oxygen into the blood – is one of the factors that sets the limit for exercise at high altitudes. On exertion, oxygen pressure in the blood falls dramatically despite the pressure in the alveoli remaining high. In well adapted mountaineers, the diffusing capacity can be almost three times higher than normal.

Skiing

In some parts of the world, the local population view skiing as a natural way of moving across country in the winter time. Tourists to these areas see it as a pleasant form of exercise, while embracing the pleasures of après-ski nightlife with greater enthusiasm. But for the true enthusiast, skiing is a test of skill and judgement and an opportunity to conquer the slopes at ever increasing speeds.

Alpine ski racing comprises downhill and slalom events. The average downhill course has a vertical descent of between 800 and 1,000 metres and a length ranging from 2.5 to 5 km, according to the nature of the terrain available. A winner's average speed is usually in excess of 80 km/h.

Slalom courses are considerably shorter than downhill ones and have a series of pairs of poles with flags, known as gates. These are carefully positioned at different angles to test the judgement, fluency of movement, power of control and skill in turning of the skier.

Mountain hazard

People who live in the mountains understand the nature of this environment, but visiting skiers often believe they can ski almost anywhere and take liberties with nature. When they do this, they lay themselves open to suffering the devastating effects of the destructive powers of avalanches.

An avalanche is triggered when snow on a slope is overloaded with piles of new snow, or the snow changes internally so its bond with the ground beneath is weakened. Any additional weight can send the mountain snow crashing down with a mighty roar.

When there is a temperature difference between land and air, say at the beginning of winter when the soil temperature is perhaps 0°C, then a natural process called constructive metamorphosis will occur.

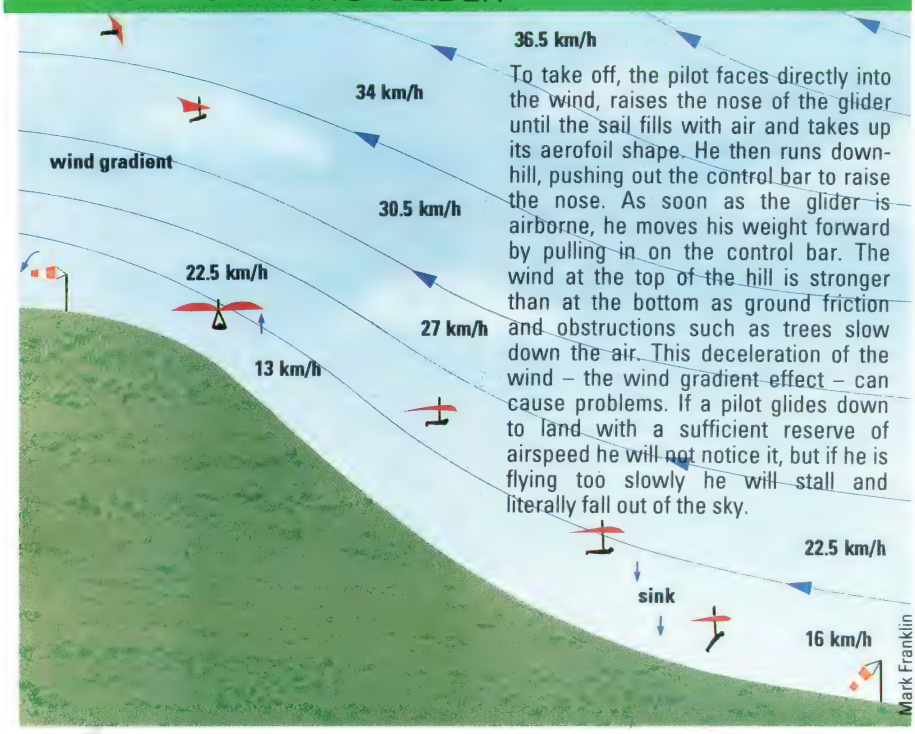
MONOSKIING

For the expert skier who has mastered the slopes on two skis, the next step is to attempt them on one. The monoski has a sandwich construction and is made of fibreglass with a polyurethane core. It can be used on piste and off-piste and handles varying snow conditions well.

Rossignol

Airwave Gliders

PILOTING A HANG-GLIDER



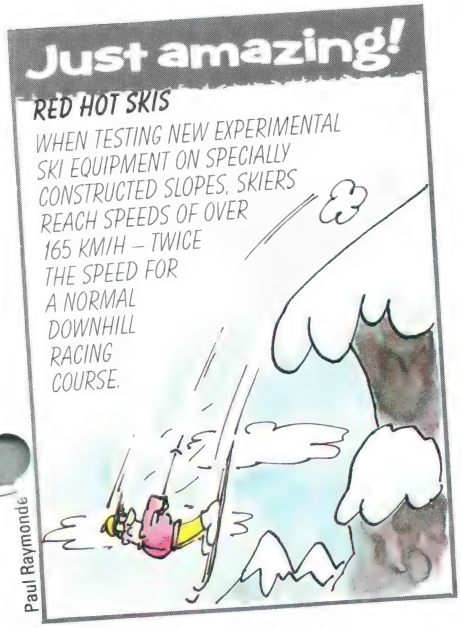
To take off, the pilot faces directly into the wind, raises the nose of the glider until the sail fills with air and takes up its aerofoil shape. He then runs downhill, pushing out the control bar to raise the nose. As soon as the glider is airborne, he moves his weight forward by pulling in on the control bar. The wind at the top of the hill is stronger than at the bottom as ground friction and obstructions such as trees slow down the air. This deceleration of the wind – the wind gradient effect – can cause problems. If a pilot glides down to land with a sufficient reserve of airspeed he will not notice it, but if he is flying too slowly he will stall and literally fall out of the sky.

Mark Franklin

***The glider soars** in the air deflected upwards by hills and ridges – these rising currents can be detected by clouds.*

Cup-shaped crystals, called depth hoar, develop and produce a very weak structure that can avalanche. The snow crystals may be more or less frozen together, but if the temperature rises above 0°C then the structure is weakened further.

New snow, which accumulates on the steepest slopes, can be blown by wind to form cornices which are huge overhanging masses of snow, around the top of mountains. On steep slopes the snow soon becomes unstable. Sunshine on fresh snow speeds up the process and without warning snow slides soon set in.



Paul Raymonde

Just as some adventurers have a desire to conquer heights, others prefer to plumb the depths – underground tunnels and caverns full of stalactites and stalagmites.

Potholing

Potholes – caves which start with vertical shafts – exist in limestone regions. In many ways, venturing underground is more dangerous than climbing. The falls can be as steep and there is the added danger of underground water.

The evolution of equipment and techniques for potholing has progressed rapidly over the last decade. Most professionals now use a fixed rope down steep climbs and along passages, and each member of the group clips himself to the rope.

The other essential piece of equipment is a harness that can be clipped on to the rope. The simplest version is a load-bearing belt, but these are made safer if used with leg loops.

Metal clamps – jammers – are used for climbing up ropes. These slide freely if pulled up, but fasten firmly on to the rope if pulled downwards. To slide down ropes, potholers use a descender. The rope is threaded from the anchor point around the bottom bobbin on the descender, then around the top bobbin before being clipped into a steel karabiner – a coupling link with a safety closure.

Well-maintained equipment can diminish the risks involved in the climbing aspect of potholing, but common sense and the correct waterproof clothing are needed to reduce the other inherent danger in this sport – water.

The water in cave passages can come nearly to the top of the passage (a duck) or even fill the passage completely (a sump). In the case of the former, often the only way to cross the passage is to hold your head to one side to keep your nostrils above water, lying on your back if the passage is shallow.

When a sump is encountered it can be free-dived using a lungful of air. But experienced potholers will never attempt this unless they are familiar with the passage.

Allsport/Vandystadt

***When free-falling,** a parachutist falls several hundred feet before releasing the parachute.*

Robert Harding Picture Library

***Buzkashi**, popular in Afghanistan, is a form of polo, involving up to 300 riders and a decapitated calf.*

***Tossing the caber** – a roughly trimmed tree trunk – is a sport restricted to Scottish Highland games.*

***Mongolian** wrestling appears similar in style to Graeco-Roman – a mix of ancient Greek and Roman – and is now accepted by the International Federation of Wrestling as a recognized sport.*

ZEFA

***Camel racing**, a sport long popular in Saudi Arabia, is now gaining popularity in Australia. A good racing camel can cost over £50,000.*

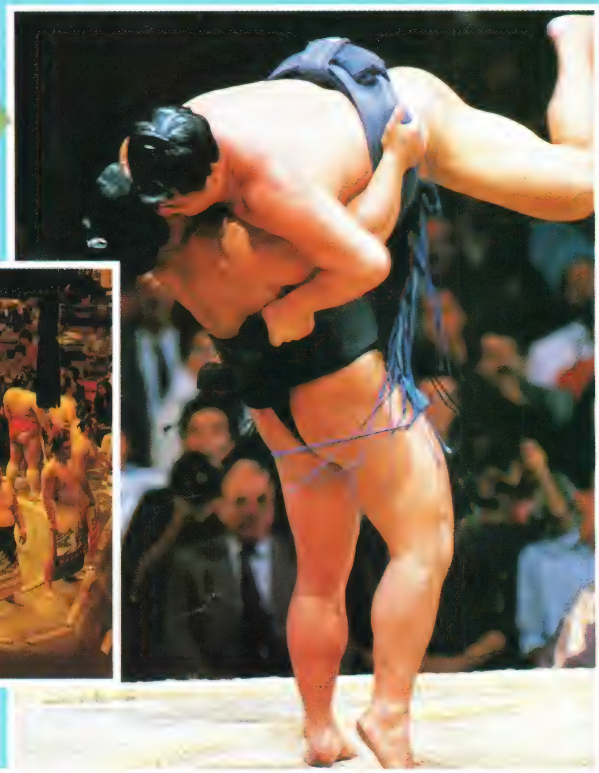
Allsport/David Cannon

Robert Harding Picture Library

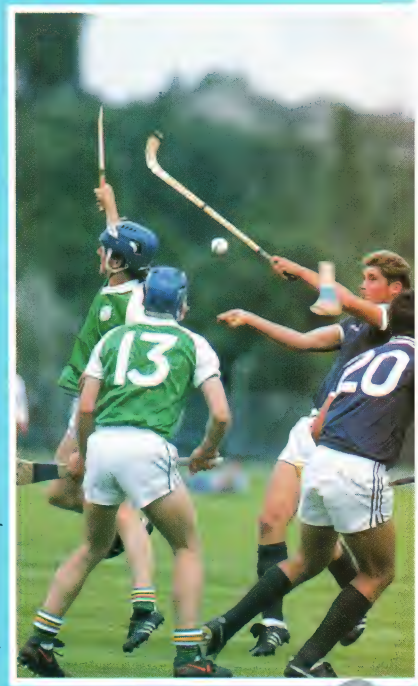
Allsport/Simon Bruty

***Boxing in Thailand** is a much faster event than Western-style boxing. Fighters are allowed to use their feet as well as their hands and a skilled boxer can knock his opponent off balance with a well aimed kick.*

***Sumo**, the traditional spectacle of Japanese wrestling, is fought out with tremendous ceremony by men all over 150 kg. Ozeki, first class wrestlers, hold a ritual entrance parade (below).*



Allsport/Vandystadt Cephas Picture Library/Nigel Blythe



Allsport/Russell Cheyne

***Shinty**, a Gaelic field game which originated in Scotland, is played by two teams of 12 men. A caman, an instrument similar to a hockey stick, is used to hit the ball during the matches.*

RIDING THE WAVES ANGLE OF ATTACK SLALOM CANOES

Conquering the Wavesssss

NEXT TO FIRE, WATER IS ONE of the greatest dangers to man if not kept under control. The power of the sea can be an irresistible challenge to some and can lead to a burning desire to utilize or harness that power.

Swimming is one of the first skills many children learn and once they have lost any initial fear of water, it can lead to a real love of all types of water sports.

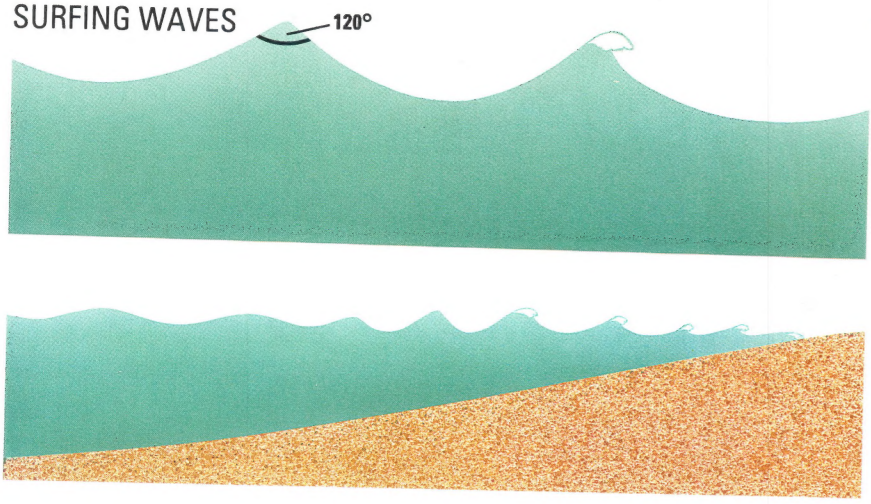
Surfing depends on waves, and waves are caused by the action of wind on water. Typically, during the day, winds blow on-shore because dry land heats up quicker than the sea. The air above the hot land rises and, by convection, draws in the wind that brings the ocean waves rolling and roaring on to the beaches. Waves form on rocky coasts as well as on sandy ones, but the best waves for surfing develop on sandy

Allsport/Cavataio

***Expert surfers** can stand towards the front of the board, but beginners find it easier to balance if they keep in the middle or near the back.*

***Slalom competitors** are pulled through a course containing six diagonally placed buoys. This calls for skill in timing, turning and crossing the wake of the towing boat.*

Colorsport



Janos Marffy

As waves grow, *their crests get steeper until they reach the angle of 120°, at which point they become unstable and break, producing whitecaps. The plunging breaker – 'dumper' as it is known in surf slang – occurs where there is an abrupt rise of the ocean bottom to shore.*

shores where the water gradually becomes shallower.

Training for surfing usually begins by body surfing. The surfer swims out from the shore and awaits a high wave. As one wave starts in towards the shore, the swimmer does a scissors kick and swims a few strokes at the crest. Then, with arms by his sides, head down and back arched, he is swept along towards the beach. The feel of the surf and the sense of balance is all part of becoming a surfer.

For a surfboard ride, the surfer paddles the surfboard out to the point where waves build up. As a big wave develops, he paddles his board ahead of it until it starts to be carried by the wave. He then stands up and guides the board across the face of the wave by shifting the weight of his body. Expert surfers can move to the front of the board, but beginners find it easier to stand at the middle or rear to keep it from turning over.

Many different styles of surfboard are used, but most are made of a tough plastic or fibreglass and are around three metres long, 75 cm wide, 10 cm deep and weigh about 5 kg. The buoyancy of the surfboard is such that surfer and board float and it is the skills of coordination and balance that lead to the long, impressive, exhilarating ride to the shore.

Windsurfing

If a couple of downward-pointing fins are attached to the board and a triangular sail attached to its top, the result is the windsurfer capable, in some hands, of wave jumping and looping the loop.

Windsurf boards now take many forms and are chosen depending on the skill of the surfer, the weather conditions they are to operate in and the performance expected.

The sail acts best when it is

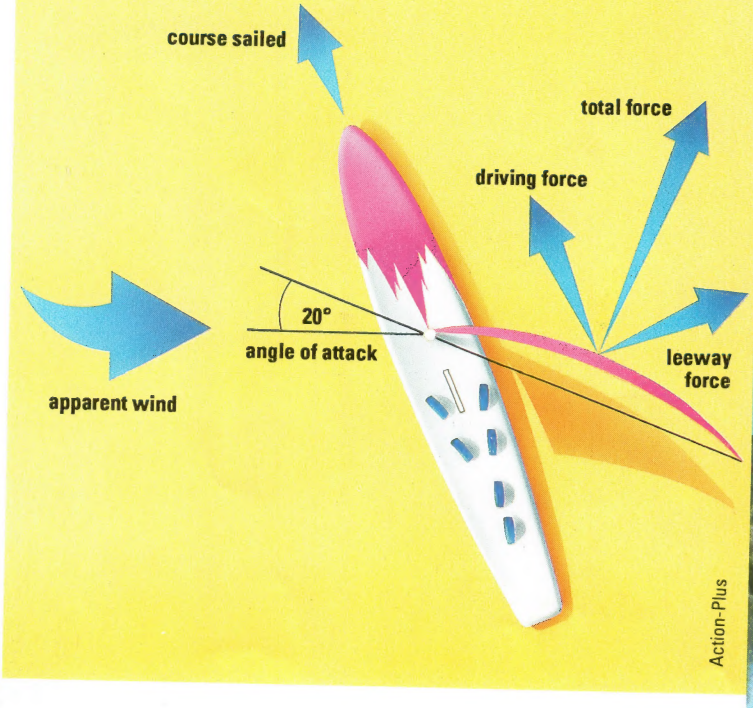
SURF TALK

Goofy-foot: a rider who surfs with his right foot forward
Hang five or **ten:** placing five or ten toes over the nose of the board
Hot-dogging: performing or showing a great deal of ability on a moving surfboard
Pipeline: space under a curling wave
Re-entry: turning up a wave then back on to the soup
Soup: foam, the result of a breaking wave
Stalling: depressing tail to slow down or stop the board
Take-off: when surfer begins to ride a wave
Wipe-out: Loss of a board, usually caused by a breaking wave

Allsport/Vince Cavataio

Looping the loop *– an expert windsurfer in Hawaii, where the waves break under almost continuous 25 km/h winds.*

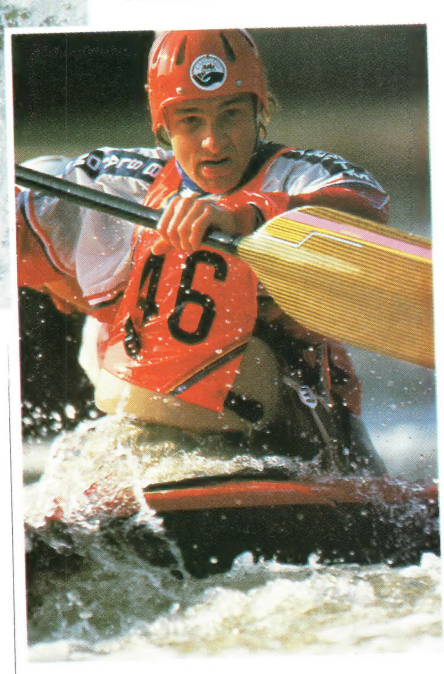
USING WIND POWER



Action-Plus

Colorsport

***Canoeing** is a collective name for a variety of sports, from white water raft racing, to single-man kayaking. In a single-man canoe, competitors roll to right themselves when the vessel overturns. In two-man canoes or inflatable racing rafts which hold several individuals, it is a case of 'abandon ship' (but not paddles!) if the vessel overturns in turbulent waters.*



Action-Plus

performing like an aerofoil and the wind is striking the mast at right-angles to the intended direction of travel. This is called a 'reach' and the maximum amount of reduced pressure is developed on the convex side of the sail – the windsurfer is literally sucked along. The importance of the daggerboard, or keel, lies in preventing the board from sliding sideways through the water and in converting the sideways push of the wind into forward motion.

Superficially, water skiing and surfing might look as though they relied on the same scientific principles. However, this is not so. The combination of surfer plus board is bouyant; that is, together they float – even when not moving. This is because the board displaces a sufficient mass of water to provide enough upthrust to stop the surfer from sinking. Water skis, by contrast, have little buoyancy. They are just flat pieces of wood or plastic, curved upwards at the leading edge and carrying footholds.

***Ideal racing conditions** are on a windless, still-water man-made course that is sufficiently deep to eliminate bottom drag – a disturbance of the water under the surface which reflects off the bottom of the boat, slowing it.*

Skiing on water

In order for the water skier to skim on the surface of the water, upthrust has to be gained from somewhere – and it comes from the pushing force of water moving at speed beneath the ski. The skill of the water skier lies in adjusting the angle of attack of the skis and the position of the body's centre of gravity so that, at all speeds, there is a dynamic balance between the pulling force provided via the rope to the skier's hands, the upthrust from the skis and the force of gravity which is trying to make the skier take a dive.

To 'get up', a speed of around 15 to 18 knots is usually needed. For this to be achieved, a boat with a 25 horsepower outboard engine or a 50 horsepower inboard engine is needed. The tow rope is about 25 metres long.

Allsport/Russell Cheyne

Canoeing

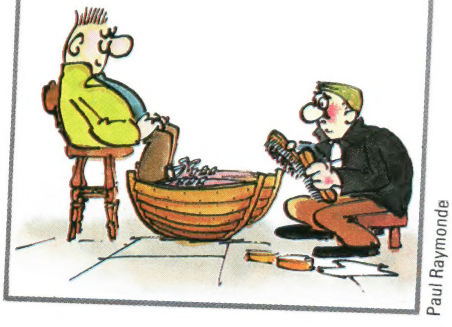
To fight – and to conquer – the ferocity of turbulent water armed only with a light plastic hull and a pair of paddles is one of the great sporting challenges. It is hard enough to navigate a canoe over a weir or down rapids. More difficult still are competitions, which involve the precise positioning of the canoe in waters that are crashing downwards at crazy angles at a rate of thousands of tonnes per minute between rocks and boulders. The canoeist must pass through gates formed by poles suspended above the river and this requires courage, timing, strength and fitness.

The canoe used for this type of competition is the Slalom type which combines lightness, manoeuvrability and toughness. Slalom canoes are made of plastics such as Kevlar and Royalex. Fibreglass was once the preferred material, but it was too susceptible to

Just amazing!

BEEN DONE BEFORE

USING OUTSIZE SHOES AS FLOATS, FRITZ WEBER WALKED OVER 300 KM ON THE SURFACE OF THE RIVER MAIN BETWEEN BEYREUTH AND MAINZ.



Paul Raymonde

cracking and holing (particularly at low temperatures) when striking rocks. The new plastics are more resilient.

Modern sports canoes have regions, fore and aft, filled with solid plastic foam. Water cannot penetrate these areas, so the canoe cannot sink. Although it is almost impossible to sink a canoe, its shape and distribution of weight make it fairly easy to turn over. With the canoeist underwater and all that buoyancy then above him it can be difficult to right it. However it is vital, if the canoeist is not to drown, that this be done as quickly and efficiently as possible. Rolling is, therefore, the first exercise a canoeist will practise, often in a swimming pool, learning the various ways of using the body's weight, together with the paddles underwater, to revolve the canoe back upright.

Rowing

Rowing must be a unique sport in that all but a minute minority of its competitors spend their time travelling facing backwards. The minute minority are tiny in number – and in size, for these are the coxes, and the first and foremost attribute of a cox is that he must be light. The less the dead-weight in a racing boat, the easier it is for the rowers. The small cox does not even have to have a large voice these days because audio links between cox and oarsmen make a normal speaking voice level perfectly adequate.

Lightness, yet great strength of hull, is achieved by extensive use of carbon fibre, both in the boat itself and in the blades.

The boat is powered forwards by a system of levers – two, four or eight. One end of each lever (blade, or oar) is in the water, the other is in the hands of an oarsman. Between the two is the rowlock, or the fulcrum of the lever. The forward, driving force is delivered to the boat through this fulcrum, but the force has its origin in the muscles of the crew, who are seated on running seats that allow maximum use to be made of not only the muscles of back and arm but of the legs as well. When each crew member is equipped with two short light oars instead of one long one, the sport is called sculling.

Allsport/Dan Smith

***Racing** to the finish, the Oxford and Cambridge boat race (left) is sedate compared to the lifeguard race in turbulent waters, where the oarsmen row without guidance.*

INTO THE FUTURE

ROCKET-PROPELLED SKI BOARD

▲ *Rocket-propelled ski boards will enable sportsmen to enjoy the pleasures of high-speed water skiing without the need for a boat to tow them.*

▲ *In hover mode, part of the engine's thrust will be directed downwards through holes in the bottom of the board, thus supporting it on a cushion of gas.*

▲ *An electronic remote-control unit strapped to the wrist will give the sportsman complete control over the machine from the standing position.*

Joe Lawrence